$3 A YEAR

PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT MAY 9, 1960

ALUMINUM DIECASTINGS...

the field widens... see page 3

here's the really new

Cleveland Worm and Gear

SPEED REDUCER

It was Designed to Provide: High Horsepower in a Smaller Unit • Centrifugally Cast Bronze Gears • Alloy Steel Worms Heat Treated By An Exclusive Process for Carrying Higher Loads • Fan Cooling for More Efficient Operation • Maximum Overhung Load-Carrying Capacity • Ribbed Housing for Maximum Strength and Heat Dissipation • Modern, Streamlined Design to Enhance Your Machine's Appearance.

Cleveland's new speed reducer line meets AGMA Standard 440.03 — which permits higher horsepower and torque ratings — provides you speed reduction at savings of 50% or more on cost per horsepower. All this, with no deviation from Cleveland's standards of quality and dependability.

Remember, this strikingly new line of fan-cooled reducers — now available from one to forty horsepower — incorporates all the design knowledge gained by Cleveland's engineers over the past 47 years — plus all the advantages of modern metallurgical techniques and advanced manufacturing processes. Consult your Cleveland Representative for the complete story on this new speed reducer — or write us direct for Bulletin No. 405. It details input horsepower and output torque ratings, service factors, application and load classifications, as well as general over-all dimensions.

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Eaton Manufacturing Company
3279 East 80th Street • Cleveland 4, Ohio

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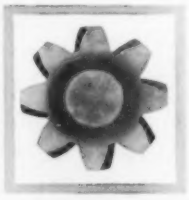
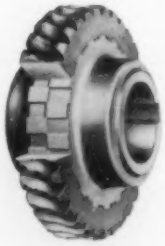


Cleveland's Worm's, heat-treated by an exclusive process, possess a high degree of hardness throughout their entire thread thickness — and well below the worm's root diameter. This gives maximum thread strength and resistance to wear without losing the advantage of a tough core of medium hardness.



Centrifugal cast bronze rims have a greater density and a higher hardness, giving increased resistance to wear and fatigue pitting. They are centrifugally cast integral with cast iron centers on 6" and smaller sizes. This permits strong mechanical keying of the two parts — without dependence on actual surface bond. Gear shaft extension diameters are especially large to permit greatly increased overhung load capacity.

Worm and gear shaft bearings are Timken taper roller type, providing adequate thrust and radial capacity. Worm bearings are mounted directly in the housing bore for greater rigidity.

CLEVELAND
Worm Gear
Speed Reducers

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

May 9, 1960 Vol. 31, No. 19

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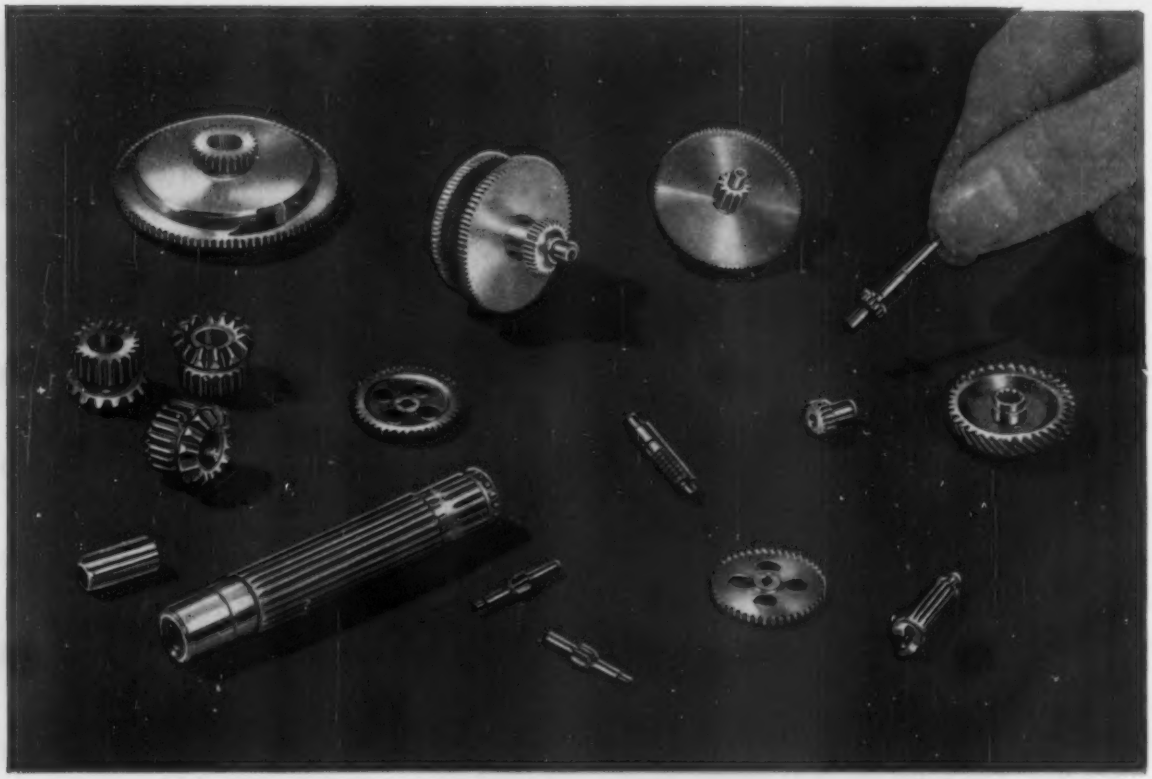

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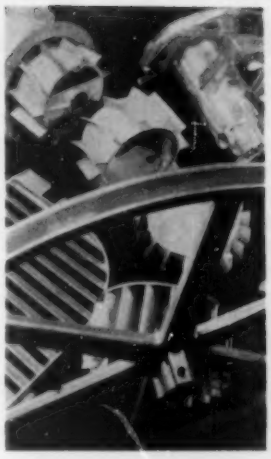
INTERESTING TO NOTE

On our cover—various forms and shapes that can be obtained with aluminum die-casting—parts for chain saws, washing machines, vacuum cleaners and aircraft. Thanks to a new alloy and an improved process described on page 48, diecastings of aluminum can now be adapted for wider applications. The components pictured on our cover were loaned to us by the Aluminum Die Casting Institute and photographed in the McGraw-Hill Photo Studio.



Those Noisy Muscles

Trade shows and conferences are hard work for everyone concerned. Manufacturers introduce their new products, speakers describe their studies, engineers look and listen until they're saturated with newness. Getting the most from the forthcoming design engineering show (at New York's Coliseum, May 23-26) is not just a matter of walking up and down aisles. As this week's Points of View panelists point out (p 26), it takes more than looking.

Perhaps you missed the IRE meeting at the Coliseum in March. One paper presented then still haunts us with its implications. It was presented by Dr Walter K. Volkers of the Millivac Instruments Div, Cohu Electronics; said that human muscles emit an electrical signal in a frequency range once used for transatlantic radio broadcasts. This discovery was made in Dr Volkers' laboratory when he applied the input electrodes of a new low-noise amplifier and a frequency scanner to his assistant's chest. First the thumping of the heart was recorded, then a "kind of rustling noise." Dr Volkers reasoned that since there was no microphone in the circuit to pick up sound, the electrodes must have been detecting electrical signals generated in the chest. The high-frequency signals had not been noticed before because they were so weak—about 10 nanovolts (0.01 microvolts). Dr Volkers concluded that muscles must be emitting signals. If this is true, such unexplained phenomena as mental telepathy and clairvoyance may someday be viewed with less skepticism than they are today.

These Inventions Were Tricky

Deciding when an idea for a new product is worth pursuing past the drawing-board stage is often a company's most difficult problem. It's distressing to approve a research budget, turn an idea into a marketable item—and then find no buyers. One method to weed good new-product ideas from bad is suggested on page 56. And if any die-hards think things were better in the good old days, they should read a book published last week—Carp's

PRODUCT ENGINEERING

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Washington, by Frank G. Carpenter—which reprints some of his Washington letters to the *Cleveland Leader* in the 1880s.

In one of these dispatches, Carp describes some of the new products that had just been granted patents. For restaurant keepers having trouble with slow eaters, a New York inventor received a patent for a moving table, with chairs attached, that transported the diner and his meal along a conveyor belt. By the time the customer should have finished his meal, he arrived at the other end of the room. There his dishes dropped off the counter and he slid from the stool. Another new product in the 1880s was an adjustable pulpit which ran up and down a shaft by means of a spring. By pressing a button, the preacher could raise or lower the platform according to his height. The invention was actually used in one of the Western churches. Supposedly, a substitute preacher had been invited to speak. "He had not been told of the peculiar arrangement in front of him upon which the Bible was placed. He was an active little man, who had a way of pounding his pulpit and leaning over and shaking his finger at the congregation. During one of his wildest moments, while in this position, he kicked the button with his knee and the pulpit, which had been set at three feet, straightway sprang up to five, carrying the kicking preacher along with it."

The Case of the Exhilarated Goat

Sometime around 850 AD, an Arabian goatherder named Kaldi noticed that several of his goats were more spirited than the rest. He watched them and observed that they alone were eating berries from a wild shrub. Being a curious man, Kaldi decided to eat some of the mysterious red berries himself and see if they might have any effect upon him. To his surprise, he felt a strange feeling of exhilaration. Kaldi described his experience to a local monk, who in turn also tried eating the red berry. He, too, felt exhilarated and had a peculiar sensation of contentment. The monk prepared a liquid concoction by grinding the berries, then boiling them in water. This drink he fed to other monks who thought it a God-given magical potion enabling them to continue their religious ceremonies late into the night without the need of sleep.

The drink, called "qahwah" (Arabic for strength), spread throughout the religious community. By the 14th century the drink had spread to Turkey where it left the holy places and made its first appearance in the marketplace. The Turks called it "Kahue"; today we call it coffee.

Perhaps no other food has affected the economic conditions of so many countries as has coffee. That strange red berry, which exhilarated goats eleven hundred years ago, is now used in the preparation of a beverage consumed by 130 million Americans. In fact, the average adult American consumes better than 20 pounds of coffee annually. In its preparing coffee faster aboard airlines, the new development described on page 54 will probably increase the per capita consumption by airline passengers.

BENEDICT A LEERBURGER JR

NEXT WEEK IN PRODUCT ENGINEERING

. . . A Manual for Reliability

This special report provides a handbook of principles based on our study of industry's reliability departments. Emphasis is placed on mechanical reliability.

. . . Selecting Counters for Digital Display

Specific suggestions are presented on counter type, speed, driving torque and life; with a case history.

. . . Faster Stress Analysis of Combined Loads on Beams

Avoiding differential equations, this method can be applied directly to simple beams and adapted for complex and continuous beams.

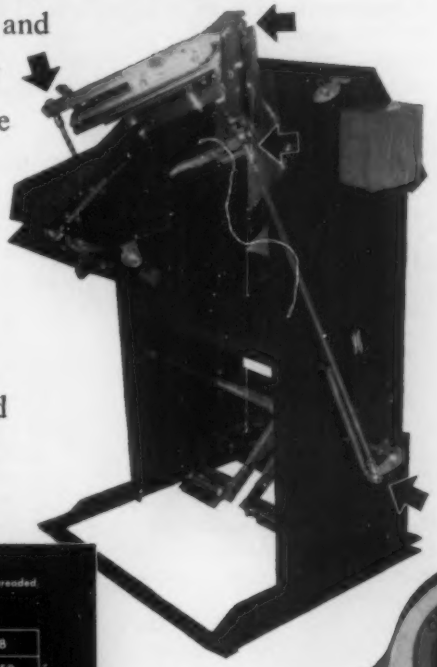
. . . 6 Ingenious Jobs for Roller Chain

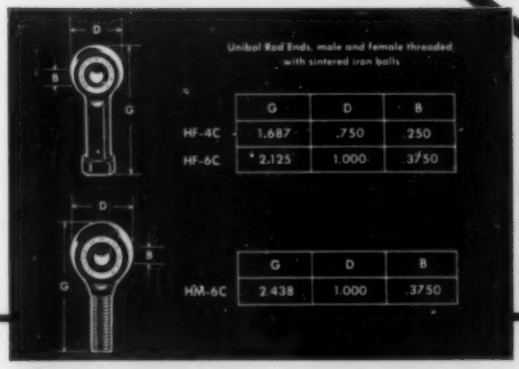
This low-cost but precision-made product can be designed-in to do tasks other than transmit power.

How to do it Better for less... with HEIM Unibal®

SPHERICAL BEARING ROD ENDS

This is the Collar Shaping and Pressing Machine made by the Reece Folding Machine Company, which is a low-priced, manually operated device used in the shirt trade for shaping and pressing collars after they are sewed together, but before being attached to the shirt.





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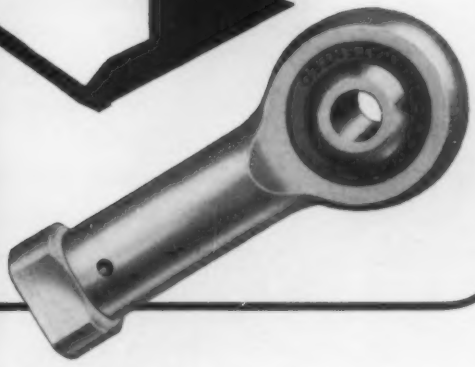
HF-6C	2.125	1.000	.3750

	G	D	B
HM-6C	2.438	1.000	.3750



Unibal Rod Ends are used in five places, and were chosen for some carefully-thought-out reasons.

- *Unibal ball joints lower the machining and assembly cost.* A male Unibal is used at the fulcrum of the triangular pressing lever at top center. This allows the pressing plates to be easily lined up with the mating surface without expensive machining to close tolerances.
- *Long wearing qualities reduce replacement costs.* Reece says, "We have been using Unibal rod ends in our machines since 1947, and as far as we know, none have had to be replaced because of wear.
- *Solve design problems economically.* The use of Unibal "gets us out of some tough design problems quite economically, simplifies co-operating parts and makes final assembly easier."
- *Maintain easy, smooth action.* Heim Unibal rod ends are used to transmit motion from the lower shaft to the pressing plates between levers moving in arcs in different planes. They maintain the easy action necessary to manual operation.
- *Correct misalignment in all directions.*

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DEVELOPMENTS TO WATCH...

Better high-temperature dielectrics coming up

Markedly improved electrical properties can be obtained from such well-known inorganics as alumina and boron nitride, Westinghouse Insulation Dept engineers report, by highly purifying the materials. They've found a way to prepare them starting from commercial 99.99% materials, and now report decidedly encouraging results.

When sintered in an induction-heated graphite crucible in an argon atmosphere, 99.99% alumina shows a dielectric constant almost identical with that of single-crystal sapphire over the full temperature range to 932 F. The loss tangent of the two materials is also almost identical, and barely half as great as that of alumina sintered in an Alundum furnace.

Similar results have been obtained with boron nitride, where the loss tangent at 60 cycles is less than 0.01, even at 932 F, for samples sintered in graphite dies degassed in a vacuum furnace at 2800 F before loading; as compared to 0.1 for samples sintered in a nitrogen atmosphere in NS grade graphite dies inductively heated at 3240 F and 850 psi.

Thermoelectric cooler claimed less costly than compressors

For cooling volumes up to 4 cu ft, new bismuth telluride thermoelectric modules are claimed to be "the most efficient as well as the most economical" system that can be produced.

The bismuth telluride crystals, which can be made in lengths to 18 in., are said to be 60% as efficient as a mechanical compressor, and coolers produced with them are basically simple in design.

Thermoelectric modules consist of *p-n* couples in series with copper electrodes, and leads projecting to and from a matrix. Matrix thickness can be varied to fit the load.

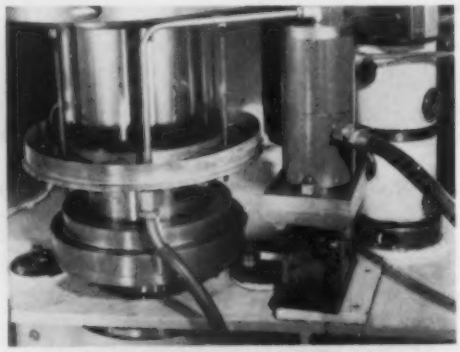
Materials Electronic Products Corp, Trenton, NJ, is making both the crystals and the modules; says it is ready to supply both in either experimental or production quantities.

Applications foreseen by the company range from portable refrigerators and home water coolers to car and plane air conditions.

New lubrication system improves bearing performance

A new system of bearing lubrication that markedly increases bearing capacity is being developed by Glacier Metal Co of Middlesex, England.

Using the test rig pictured here, Glacier engineers say they have found that, with high radial loading, pressure drives the cap half of the bearing away from the shaft, collapsing the oil film on that side. This cavity or collapsed area is then carried around the bearing at about half running speed, appearing (in a 2-stroke cycle) on the other side of the bearing at the next peak load.



BEARING TEST RIG shows oil-injection pump (right) that gives protective cushion of oil. Transparent bearing (left) shows effect of injection.

To get around this problem, Glacier has devised a ram-type, positive-displacement pump to force a predetermined volume of lubricant into the bearing just before the load is applied. This fills the cavities, providing a thick oil cushion at the point of peak load. Pump and oil requirements are not high. Even for a large (1000 hp) diesel, only about 1 cc of oil is needed per bearing per cycle, and pumps require about 2 hp. However, a separate pump is needed for each bearing since injection must be spread over about 60° of crank angle, and phasing generally overlaps.

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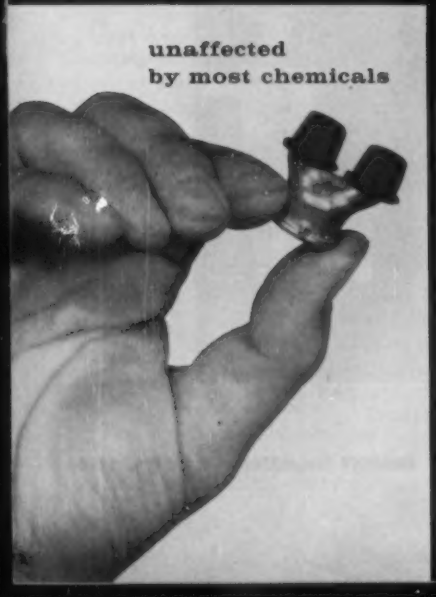

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Stronger paper "engineered" by USDA

With a new compound made from starch, paper that is stronger both wet and dry can be made on a production basis. In tests at the USDA Northern Utilization R & D Div, papers so treated supported loads as much as 10 times as great as those which break untreated papers; and, after soaking in water for 30 min., treated papers still retained about 30% of their dry strength. Dry tensile strength is also increased. But, says USDA, there is a slight decrease in dry tear strength.

The treating compound is dialdehyde starch, a resin created by acid treatment of wheat and corn starches. This material itself is a new one, developed by USDA, and just now reaching full commercial production. In addition to its use in paper, it shows considerable promise for use in industrial binders and cementing agents and in protective coatings. Full information on it may be obtained from USDA or from Miles Chemical Co and Abbott Laboratories, which have been licensed to produce dialdehyde starch commercially.

(Note: For more on paper for electrical insulation, lamination, and related applications, see *PE*—Feb 16 '59, p 50; Apr 18 '60 p 9.)

Improved welding alloy for bronze claimed by Austrians

Bronze welding wire containing manganese, silicon, traces of phosphorus and boron;—but no zinc—gives much improved flow and shrinkage properties, and excellent resistance to sea water and acids, say Austrian metallurgists. Three new filler wires, one low-tin (5 to 7%); the other two containing 12 to 15% tin, plus 0.3 to 0.5% silicon, have been developed. They can be used as spraycoating materials as well as for gas and air welding.

Titanium headed for electrical jobs

Heating elements and wide-temperature-range electrical wiring are among the electrical applications for titanium being investigated by Crucible Steel Co.

Crucible points out that several titanium alloys (notably C-135 AMo and C-120 AV) have significantly higher resistivity than commercial nickel-chromium heating-element wire, and show little change over a wide temperature range (0 to 1400 F). Furthermore, Crucible believes, oxidation would not pose serious problems.

In applications where heating elements work at relatively low temperature, the rate of oxygen diffusion is so slow that it should have little effect; and the nonconductive oxide that forms on titanium at such temperatures might be a distinct advantage.

At higher temperatures—above 1300 F—rapid oxidation would be a factor. But, Crucible believes, nickel coatings could be developed to overcome this difficulty.

More ceramic heat-exchangers to be tested

Another ceramic is being readied for testing as a material of construction for heat exchangers. This time, it's fused silica. Georgia Tech's Engineering Experiment Station says it has produced experimental slip-cast tube and shell units at the request of the Bureau of Mines; reports that complex shapes can be obtained with relative ease. Advantage as compared to alumina tubing already under test is ease of casting; but fused silica also offers high thermal conductivity at relatively low temperatures and good thermal shock resistance.—ARG

FUSED SILICA HEAT EXCHANGERS can be slip-cast in complex shapes like this.

WHAT'S HAPPENING IN RESEARCH . . .

High-melting tin alloys announced in Britain

High-tin alloys that stand temperatures above 4000 F are reported by Britain's Tin Research Institute. These alloys are almost eutectics-in-reverse. Instead of showing a lower melting point than either of their components, these are compositions that show a higher melting point. One example is a tin-zirconium alloy that melts above 4100 F, though its basic components melt at 450 F and 3350 F. Similar compounds have been obtained with titanium, TRI says, but these are brittle at room temperature—and will have to be fabricated by powder metallurgy techniques.

The explanation of their refractory behavior: Apparently these compounds are similar in structure to transition-metal carbides and silicides, noted for their high melting points. To find out more about them, further studies are underway.

Note: For more on recent tin research see *PE*—Apr 25, p 8.

Three keys to better semiconductors

Band gap, mobility, and thermal conductivity are the three most important parameters to consider when choosing semiconductors for specific applications, says Rowland E. Johnson of Texas Instruments.

Band gap represents, he says, "the forbidden energy gap between the valence band and the conduction band in a semiconductor." It affects the operating temperatures; the sensitivity to light wavelengths; and, in electroluminescent devices, the wavelength of emitted light. In general, the wider the band gap, the higher the operating temperature. Thus, germanium, with a band gap of only 0.7 electron volts, will operate only to about 150 F; while silicon, with a 1.1-ev band gap can go nearly twice that high.

Mobility represents the velocity of charge carriers in a material in the presence of an electrical field; and the higher it is, the better. In transistors and diodes, it increases operating frequency. In thermoelectric devices, it reduces resistivity and power loss.

Thermal conductivity is important primarily in thermoelectric devices, since excessive thermal losses decrease efficiency.

These parameters can not only be used to select the most promising material from those presently available, but also to guide research on new materials.

As Johnson pointed out to an AIEE Regional Meeting, band gap is clearly related to the position of elements in the periodic table. Only those elements in Groups IIIA, IVA, VA and VIA (and not even all of these) have high enough band gaps to rate consideration; and only four, carbon (diamond), silicon, germanium, and tin can serve as elemental semiconductors. There are, however, about 20 simple binary compounds of these elements which may be used; and many ternary and quaternary combinations.

Materials give problems in a vacuum

The fact that outer space provides a better vacuum than can be achieved in most laboratories may someday prove extremely useful. Right now, though, it's creating a lot of problems.

The fact that magnesium sublimes at only slightly elevated temperatures under space-vacuum conditions has already been recognized (*PE*—Aug 10 '59 p 12). But that's only the beginning. As Leonard D. Jaffee of the CIT Jet Propulsion Lab points out, evaporation of such metals and semiconductors as cadmium, lithium, and selenium is significant even at room temperature under space conditions.

Oils and oil components of greases also evaporate, and solid lubricants simply fail to do their job. Many polymers decompose too.

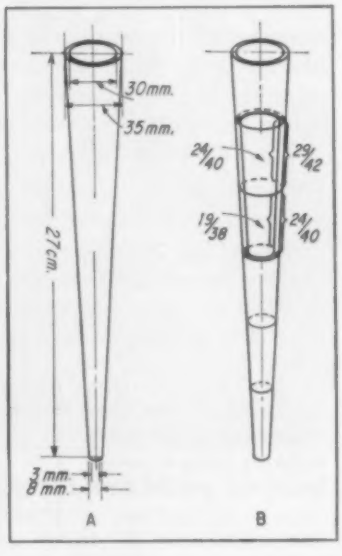
It's going to take a lot of research, the experts agree, before these problems, and others related to space travel —effects of ultraviolet and cosmic radiation, meteoric dust, and the like —are finally solved.

brief . . .

The best antioxidant for rubber is blend of two major types, says J. Payne of Monsanto Chemical Company's British laboratories. Tests of two types of compounds (paraphenylenes and dihydroquinolines), normally used singly as antioxidants, show they act in quite different ways. Far greater protection can be obtained by combining them than by using either alone. Field tests on tires have confirmed the original laboratory findings, and a tentative explanation for the difference between the compounds has been proposed. Now, work is underway to provide a fuller explanation and thus develop still better blends. —ARG

Cut-to-size cones for do-it-yourself lab

Tapered plastic cones that can be sliced to size for use as adapters on laboratory equipment have been designed by Burdick & Jackson of Muskegon, Mich. These are heat-resistant polypropylene cylinders, 27 cm long; with 3 mm ID, 8 mm OD at the apex; and 30 mm ID, 35 mm OD at the base. They'll fit all stopcock sizes from 34/45 to 10/20; and, if sliced into 50-mm sections, will form a series of 6 concentric bushings, each able to bridge two adjacent joint sizes. They can be used as funnels, drip tips, thermometer supports, tubing connectors. Price $1.50 each, for a dozen.



BUSHINGS, FUNNELS AND COUPLINGS can be made by slicing polypropylene cones as indicated here.

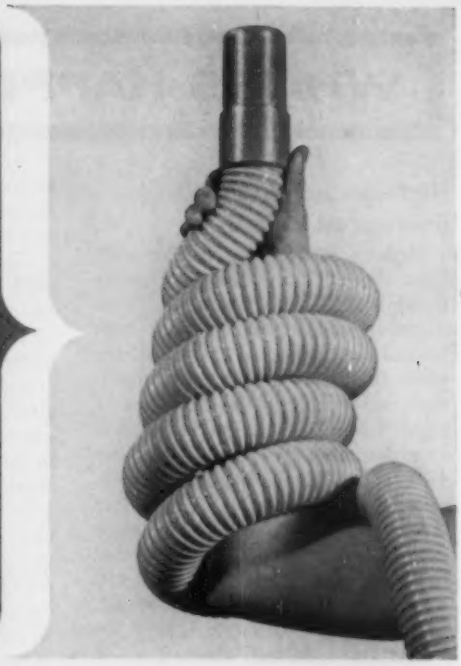
NEW from Dayton Dayflex

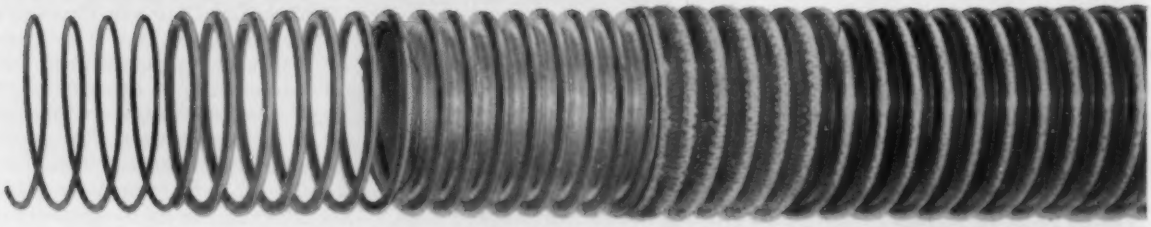
DAYCO

Nylaflex*

THE MOST RUGGED PLASTIC HOSE MADE!

Built to bend in its own diameter. An economical solution to many difficult design problems.





CORE: insulated spiral of high tensile bronze plated spring steel wire, provides non-collapsible, non-kinking "muscle" action.

INSULATION: specially compounded plastic, chemical and abrasion resistant, extends life of hose.

INNER SLEEVE: attached to spiral core, made of chemical and abrasion resistant non-porous seamless vinyl.

EXCLUSIVE NYLON SLEEVE: imparts great flexibility and strength, absorbs and cushions tensions and compressions, acts as insulator to prevent shrinking and cracking.

OUTER SLEEVE: tough, premium grade, non-porous P.V.C. of great tensile strength. Impervious to chemical attack, resists wear, scuffing and weather.

**Registered Trade Mark. Patented and Patents Pending.*

Never before has there been a non-collapsible hose like Dayco Nylaflex. Exclusive NYLON reinforcement imparts flexibility with great tensile strength for longer life. Lightweight yet rugged, it's chemical and abrasion resistant.

Presently used on household vacuum cleaners and swimming pool systems, Nylaflex has possible Air Conditioning, Refrigeration, Washing Machine, Clothes Dryer, Hair Dryer, and Industrial Vacuum Applications as well. Can be made in many diameters and lengths to meet your specifications.

OTHER DAYTON HOSE FOR INDUSTRY

Dayflex** Current-Carrying Hose. *A unique double wire construction provides both structural strength and electrical capacity. Carries 110-115 volts and is UL approved.*

Dayflex Plastic Hose. *A proven component. Known throughout the appliance industry for its economy and non-collapsible efficiency.*

Dayton Dayflex Plastics *offers technical assistance to develop new uses for all its non-collapsible hose. Write for a free sample of new Nylaflex and technical details today. The Dayton Dayflex Plastics Company, Dayton 1, Ohio.*

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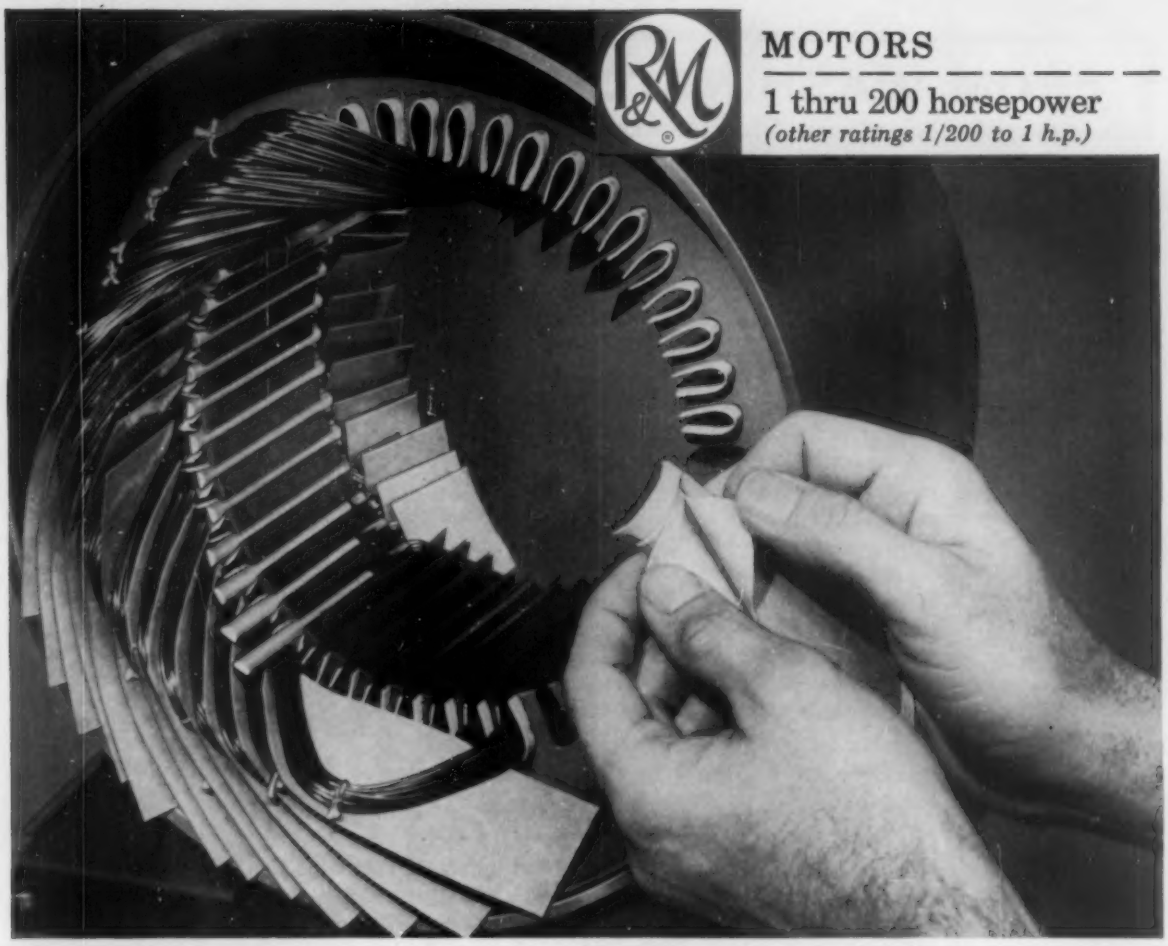
Nylaflex and Dayflex offer innumerable opportunities as flexible piping or venting for industry and the home

Dayton Dayflex Plastics Co.

Division of Dayco Corporation, Dayton 1, Ohio ***(formerly Dayton Rubber)***

Dayco HEADQUARTERS FOR **NEW** IDEAS



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 PRE

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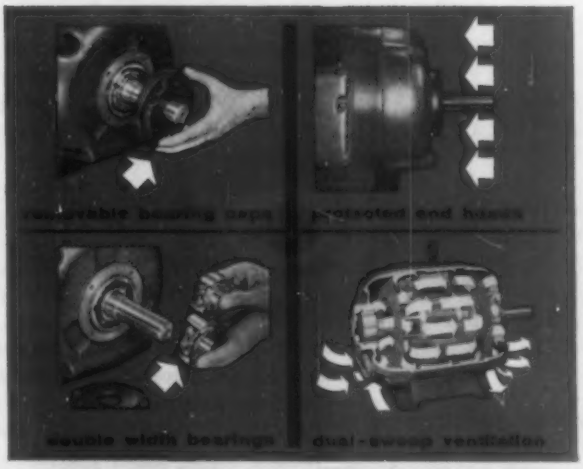

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motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

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CIRCLE 11 ON READER SERVICE CARD

FROM WASHINGTON . . .

NSF ponders building telescope almost ½ mile in diameter

A panel of scientists is studying prospects of building a huge radiotelescope with a parabolic, steerable dish between 2000-2500 ft dia—three to four times larger than any known radiotelescope of this type. The world's largest so far is the 600-ft circular-dish telescope being built by Navy at Sugar Grove, W Va.

Dr Otto Struve, director of the National Science Foundation's National Radio Astronomy Observatory at Green Bank, W Va, has proposed construction of the superdisk. Its cost is estimated at around $100 million, to be spread over a four or five-year period.

Such a telescope would give scientists a far deeper view into the cosmos. Just how far out into space the big disk could penetrate has not been determined. However, the Navy, with its 600-ft telescope, claims ability to reach out some 38 billion light years into space.

Construction of Struve's 'scope would be a tremendous engineering challenge, its backers say. The huge dish, nearly a half-mile in dia, would have to be built so that no sagging occurred during rotation of the scope to assure precision performance.

A decision on whether the project will be undertaken is expected in the next few months.

Boeing develops nuclear jet engine for 100-knot submarine

There is a new entry in the field of "push-type" submarines with speeds up to 100 knots. Boeing Aircraft Co has filed for a patent on a nuclear jet engine that it says may hold the answer to submarine and surface ship speeds in this speed range.

Boeing's system would pass water under ram pressure through a nuclear heat exchanger, then through a turbine and out through the nozzle of the engine.

It is the high velocity of the steam and water channeled through a 2-ft nozzle opening that would propel a sub at more than 100 knots, Boeing predicts.

The system is still in the very early stages of development. L. J. McMurtrey, systems manager in Boeing's Advance Design Section at Wichita, Kan, is inventor of the system.

No Navy money has gone into the project. So far, Boeing has financed the project on its own. It is still too early to determine how interested Navy is in it.

Navy has a project of its own along similar lines. Although this project is under tight security wraps, Navy admits that its David Taylor Model Basin is doing work on a system in which water would be taken into a submarine through a "hole in the bow," passed through a heat exchanger, then channeled out through side or end openings under high pressure.

NSPE disputes statement of Comptroller General

"Highly erroneous and misleading" advice concerning consulting engineers was given to Congress by the Comptroller General of the US, the National Society of Professional Engineers has charged.

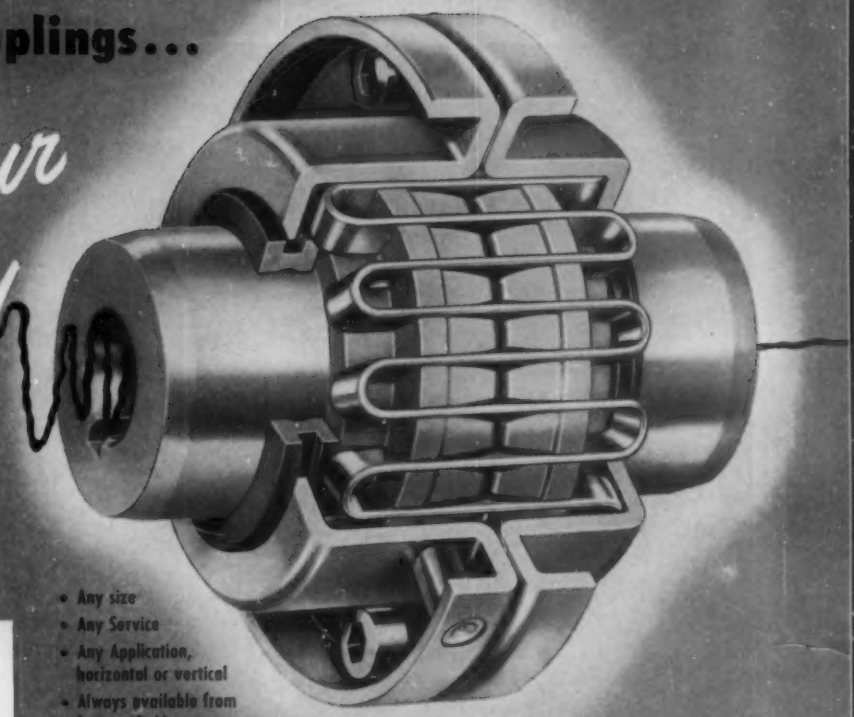
The society took issue with recent testimony by Joseph Campbell in which he stated to the House Appropriations Committee that "the extensive use of consulting engineers substantially and unnecessarily increased the cost of engineering."

Paul H. Robbins, executive director of the engineering group, cited a newly published survey by its Functional Section for Consulting Engineers in Private Practice, which "clearly refutes any statements or implications by Campbell that it is less expensive to use staff employes for engineering design as contrasted with contracting for the same work with private consulting engineers."

CIRCLE 13 ON READER SERVICE CARD→

Falk Steelflex Couplings...

Protect your machinery in 2 ways



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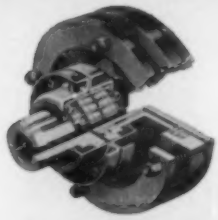
- Always available from factory, field or distributor stocks



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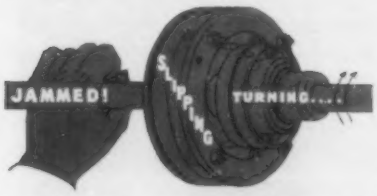
Falk Controlled Torque Couplings prevent damage from overloads

In applications where danger from overloads exists, use the FALK Type FT Controlled Torque Coupling. The Type FT has all the features and advantages of standard FALK Steelflex couplings—and, in addition, has an adjustable friction slip clutch, enabling the operator to set the coupling to slip at any predetermined overload.

This controlled-torque principle not only prevents transmission of dangerous shocks and limits overloads; it eliminates the breaking of shafts caused by jamming of driven equipment.

An outstanding advantage of the Type FT Coupling is that, as soon as the cause of the overload is removed, the entire coupling will rotate and transmit power without replacing parts or repairing coupling.



There's real economy in using Type FT Controlled Torque Couplings. Many users have reported that these couplings paid for themselves the very first time they slipped (under overload) because of the protection against damaged driving or driven machinery!

...cost less per year of service!

You get *double protection* when you connect your driving and driven machinery with a Falk Steelflex Coupling—the all-steel coupling with the exclusive grid-groove design! First, its *torsional resilience* smothers shock and vibration; and second, the Steelflex design prevents damage and lowered efficiency by accommodating shaft misalignment.

Why have increasing numbers of key men in industry standardized on Falk Steelflex Couplings? Their experience has proved that Falk Steelflex Couplings prolong the service life of their machinery... are trouble-free and need minimum maintenance... are easy to install, lubricate and disconnect... and *cost less per year of service* than ordinary couplings.

One basic Steelflex design—the type F, in its many sizes—is adaptable to more than 90% of all industrial applications. For applications involving danger from overloads, Modified Type FT Controlled Torque couplings (see column at left) are ideally suited. There are numerous other special or dual purpose Steelflex couplings for unusual applications. **Write to Department 247** for engineering bulletin, including selection and dimension tables.

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FALK

...a good name in industry

MANUFACTURERS OF:

- Motoreducers
- Speed Reducers
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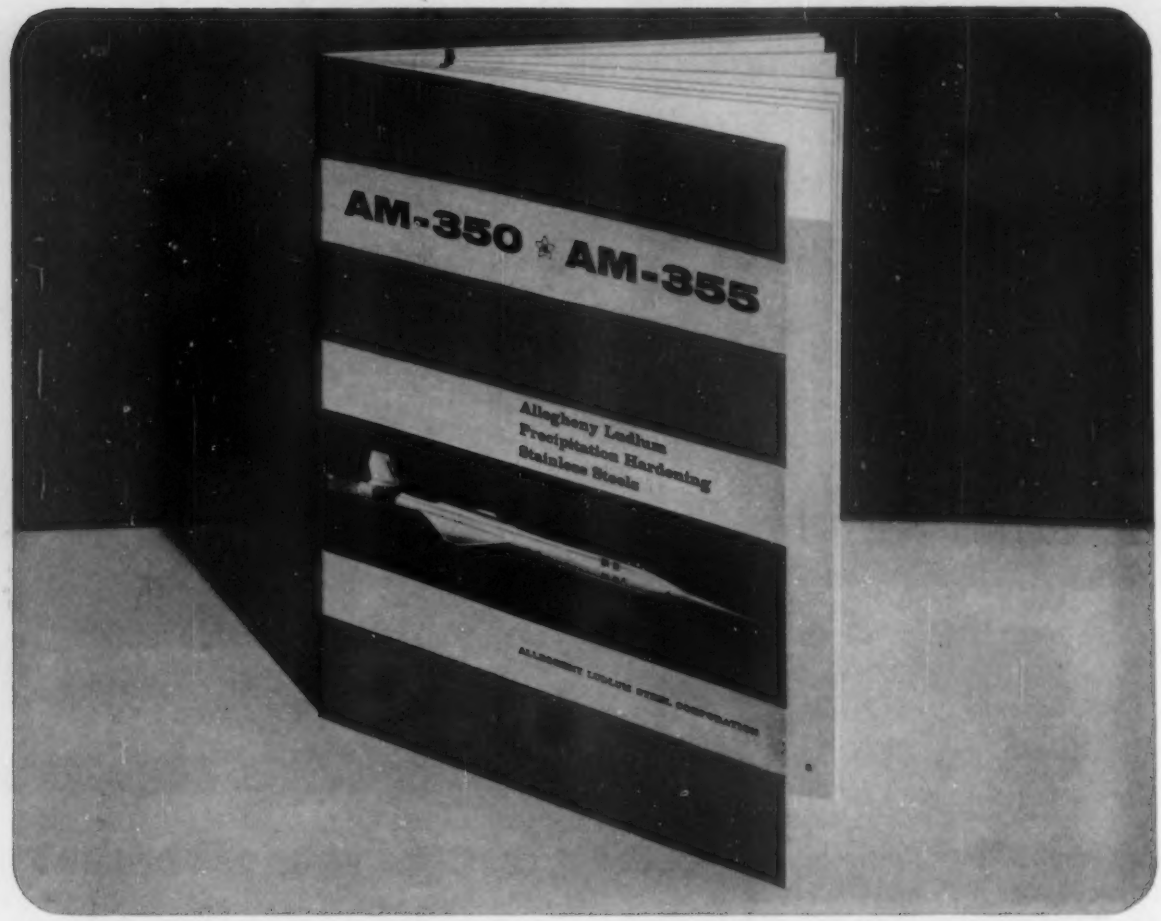
Experience**—the added alloy in **Allegheny Stainless



New booklet on A-L's precipitation-hardening stainless steels, AM-350 and AM-355

A tool for anyone interested in high strength-to-weight metals

In this technical booklet, you get the facts on Allegheny Ludlum's precipitation hardening stainless steels, AM-350 and AM-355, metals developed for space age requirements.

AM-350 and AM-355 combine these unusual qualities. They are easy to fabricate. Have high strength-to-weight ratios at room and elevated temperatures combined with excellent resistance to corrosion.

The physical and mechanical properties of the two metals are described in 33 charts and tables. Included are heat-treatment and fabrication data, eight photomicrographs and a section on corrosion resistance with representative values in selected environments.

It's jam-packed with data. For your free copy, see your A-L representative or write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. PE-5.*

955

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

THE ENGINEERING WEEK

Universities List Brief Review Courses for Busy Engineers

NEW YORK—Again this year, PRODUCT ENGINEERING is presenting an outline of short, intensive courses that are being offered by the nation's universities this summer. Planned especially for working engineers, the courses described below are expected to help keep these busy men abreast of latest developments in today's fast-moving technology.

Massachusetts Institute of Technology has scheduled five courses in the mechanical engineering area. They are:

Fluid Power Control, with special emphasis on high-pressure pneumatic components that will be suitable for complete hot-gas control systems in future vehicles. June 14-June 24. Tuition: $300.

Industrial Photoelasticity, for beginners, covering standard two-dimensional procedures and some recent three-dimensional techniques. June 27-July 11. Tuition: $200.

Modern Developments in Heat Transfer, with emphasis on underlying principles and their application to engineering problems. Content assumes student has taken a one-semester undergraduate course in heat transfer or has the equivalent in experience. June 27-July 8. Tuition: $300.

Fundamentals of Strain-gage Techniques, dealing with wire and foil strain gages and their associated instrumentation. Geared to beginners, the course will also cover applications at extreme temperatures. July 11-July 15. Tuition: $175.

Applications of Strain-gage Techniques, laboratory problems to supplement fundamentals given earlier. July 18-July 22. Tuition: $175.

MIT will offer many other courses in metallurgy, electrical engineering, and writing scientific and engineering reports. For information, contact Prof James M. Austin, Director of Summer Sessions, Room 7-101, Massachusetts Institute of Technology, Cambridge 39, Mass.

New York Univ's College of Engineering has scheduled three sessions this summer—all open to anyone interested:

Vacuum Metallurgy Conference, June 1-June 3, covering R&D advances in vacuum metallurgy. Approximately 200 students. Fees: $20.

Thermoelectric Materials and Devices, June 13-June 17, a course to bring students abreast of theory and state of art of materials and devices that are based on thermoelectric effects. Open to 200 students. Fee: $20.

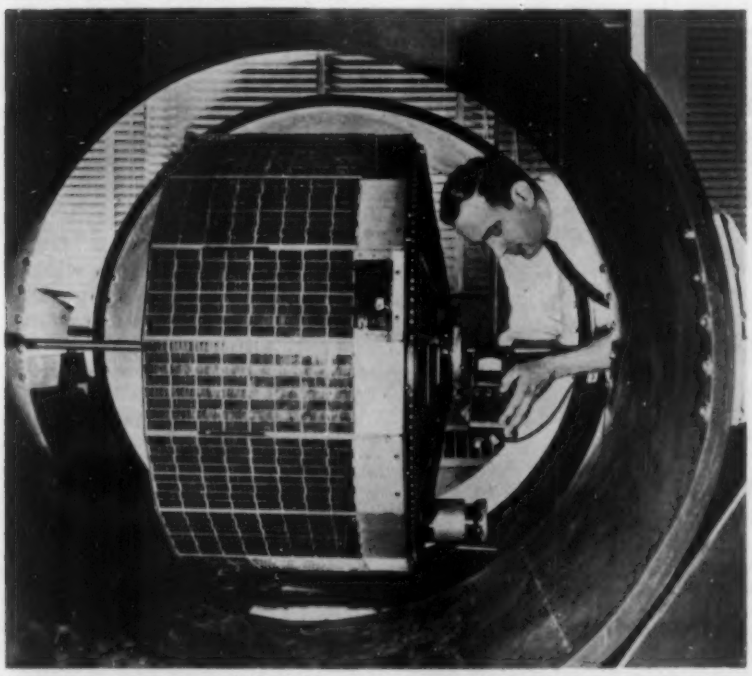
Titanium Metallurgy Conference, Sep 12-Sep 13, will present current progress on titanium technology. Open to 200 students. Fee: $15.

For additional information, contact Mel Berk, New York Univ, College of Engineering, NY 53.

Cornell Univ will hold its seventh Industrial Engineering Seminars this year, June 14-June 17. Divided into several interest groups, the sessions will encourage group participation as well as presentations by specialists in the fields. Of special interest is an engineering-administration seminar covering communications problems, development of engineers as supervisors, and cost control for project managers. Other seminars are devoted to industrial management, operations management of the smaller company, work measurement, systems simulation with digital computers, and statistical reliability analysis: theory and application. Registration fees are $125. For further information, contact J. W. Gavett, Upson Hall, Cornell Univ, Ithaca, NY.

Colorado State Univ will conduct its third Institute in Technical and Industrial Communications, July 8-July 10. An intensive lecture and workshop program, the course is de-

Solar-celled Weather Satellite



You see here only part of the 9200 silicon solar cells mounted on top and side of this Tiros weather-eye satellite. They generate power directly from sunlight to operate the miniaturized television equipment inside. The technician at RCA's Astro-electronic Products Div is using a special magnetic drag device to measure the effect of the earth's magnetic field on the vehicle. Solar cells are a product of International Rectifier Corp.

signed for persons engaged in writing reports, manuals, articles and other technical communications. Fee: $50. For information, contact Director, Institute of Technical and Industrial Communications, Colorado State Univ, Fort Collins, Colo.

University of Michigan is offering 23 courses covering wide range of engineering problems. Of special interest:

Analysis and Synthesis of Mechanisms for mechanical designers seeking additional mathematical tools. Subject matter will include analysis of position, velocity and acceleration of mechanisms using two- and three-dimension vector analysis, Raven's equations and IBM 704 computers, etc. June 27-July 1. Fee: $150.

Topics in Multiphase Flow, including horizontal and vertical flow of liquid and gas mixtures, fluid dynamics of spray formation, and hydraulics of nozzle flow. June 27-July 1. Fee: $150.

Freehand, Pictorial, Engineering Design Sketching, covering such drawings as isometric, dimetric, cavalier, etc, to aid practicing engineers in freehand sketching and more effective communication with colleagues. Aug 1-Aug 12. Fee: $150.

Other courses include Theory of Computing-machine Design; Industrial Engineering Developments; Automatic Control; Quality Control; Models and Simulation in Operations Research and Semiconductors. For information, contact R. E. Carroll, Coordinator, Engineering Summer Conferences, Univ of Michigan, Ann Arbor, Mich.

Johns Hopkins Univ's intensive course in operations research and systems engineering will be held again this year, June 6-June 17. Slanted toward requirements of top executives during the first 3 days, the remaining days are pinpointed to managerial and technical personnel who direct subordinates in these areas. Content includes computer programming, design of experiments, game theory, etc. Fee: $50 a day; full course, $300.

Pennsylvania State Univ will offer 10 engineering seminars. Of special interest are:

Design Engineering, June 12-June 17, to stimulate imaginative and creative thought in design engineering. A daily workshop will help students solve practical design problems encountered in industry. Fee: $80.

Machinability, with emphasis on application and handling of new difficult-to-machine materials. June 5-June 10. Fee: $90.

Other courses include Electrical Contacts, Underwater Missile Engineering and R & D Management. For information write Engineering Seminars, Conference Center, The Pennsylvania State Univ, University Park, Penna.

Univ of Pennsylvania's Moore School of Electrical Engineering will hold a special summer session on recent developments in electrical engineering. The three 2-week programs between June 20 and July 16 will cover Modern Radar Techniques; New Devices in Amplifying and Switching; and Numerical Analysis for Digital Computers —all with emphasis on recent developments. Fee: $250 per program.

Case Institute of Technology is offering 7 special programs in 1960, including sessions on digital control systems engineering, June 6-June 17, fee: $300; Mathematics for Operations Research, May 23-May 27, fee: $200; and Workshop in Operations Research, May 31-June 10, fee: $400. For information contact Dr James E. Hooper, Director of Special Programs, Case Institute of Technology, University Circle, Cleveland 6.

Univ of California will present four summer courses. One on Rarefied-gas Dynamics, July 18-July 29, reviews latest theoretical and experimental developments in aerodynamics at ultra-high altitudes. Fee: $250. Others in nuclear sciences includes a two-week basic course and a four-week advanced course in nuclear technology for industry. The first runs June 6-June 17. Fee is $250. The advanced session runs June 20-July 15. Fee is $600. For information contact Engineering and Sciences Extension, 2451 Bancroft Way, Univ of Calif, Berkeley 4, Calif.

Purdue Univ course offerings include:

Design of Experiments, covering such topics as analysis of variance, principles of experimental design, split-plot design, incomplete-block designs. June 7-June 17. Fee: $200.

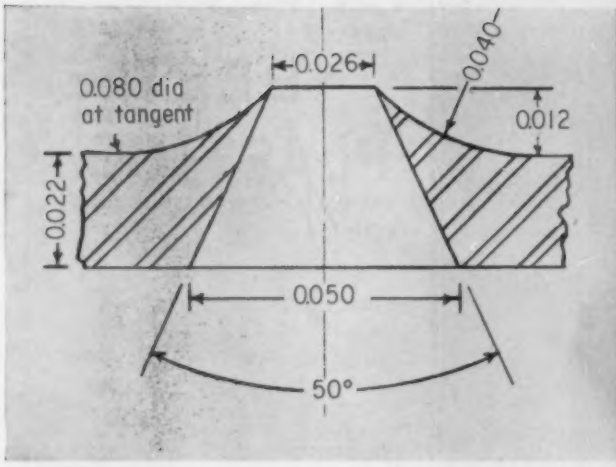
Statistical Methods and Advanced Quality Control for design and production engineers, and lab workers. Content includes significance tests, linear correlation, multiple correlation. June 7-June 17. Fee: $175.

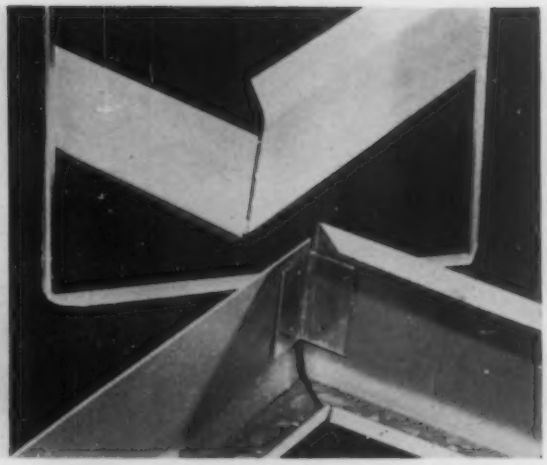
Operations-research methods covering probability and statistics, waiting-line models, linear programing, dynamic programing. June 6-June 16. Fee: $200.

For information, contact University Extension Administration, Memorial Center, Room 110, Purdue Univ, Lafayette, Ind. ■

FAA Certifies Lockheed-Azcarate Airplane

Lockheed is reentering the light-plane field—after more than a decade—with this single-engine craft that will be produced on two continents. American production, recently certified by the FAA, will be at the new San Luis Potosi factory of Lockheed-Azcarate, S. A., in Mexico. It will be built in Italy by Areonautica Macchi. The plane will carry up to six persons, or about 1000 lb of cargo. It can be converted to aerial ambulance or adapted for agricultural useage. Powered by a 260-hp turbo-supercharged Continental engine, its top speed at 15,000 ft is 167 mph; stall speed, 53 mph. Takeoff distance, at 7000 ft over a 50-ft obstacle, is 1350 ft at 3532-lb gross weight. Lockheed designed to meet requirements laid down by General Azcarate, director-general of LASA, for a hard-working "bush" airplane capable of performing from short, rough landing strips in mountainous terrain.





Magnetic-force Welding Adapted for Coated Steels

CINCINNATI—A method of precision resistance welding developed for vinyl-laminated steel, has been further refined to permit welding of steel precoated with paints, vinyl plastisols, acrylic finishes and wood veneer. These coatings are damaged by temperatures over 300 F, so a very short welding time is required to avoid marking the coating. Developed by Precision Welder and Flexopress Corp for welding electrical contacts, magnetic-force welding is a form of projection welding in which application of pressure and resistance heating are very closely synchronized. To weld metals clad with vinyl, synchronous controls have been designed to actuate the force current independently of the weld current.

IT'S MORE THAN TIMING

Timing is only one factor, say P W & F engineers. Each coated material requires just the right amount of kinetic energy in the followup system to set down the projections without excessively deforming the coated steel. This energy control, obtained by changing the weight of the magnet armature that delivers the forging blow, is the key to welding prepainted steel—where coating thicknesses are as low as 0.5 mil, say the engineers.

Projection design is also important. Resistance heating is concentrated in a ring, causing less heat damage than when concentrated at a central point. Sketched above is the projection design P W & F researchers have established for prepainted mild steel 0.015 in. thick. Photo at right shows undamaged finish that results when 0.022-in. steel corner bracket is welded to 0.015 steel frame with lithographed wood pattern. P W & F reports that progress is being made on magnetic-force welding of preplated steels, but that it is not yet possible to join these materials without faint discoloration appearing. ■

10 Times Longer Life Claimed for Self-oiled Bearing

DETROIT—A new bearing with self-contained lubrication has been developed by Tann Bearing Co, Div of Tann Corp. It's a sleeve bearing and its assembly is said to have a lifetime expectancy "10 times that of ballbearings." Tann says it will prove useful in household appliances and in other mechanisms where maintenance is difficult or unreliable. The new bearing is said to have low vibration and noise levels; and resistance to humidity, dust and gritty atmosphere.

Designed as a standard off-the-shelf component in bore sizes from 8 to 40 millimeters, this sleeve bearing utilizes a mixture of lubricating oil and cellular fibers, described as an "internally regulated, self-metering oil system," and called Permawick.

The bearing itself is an inner and outer race separated by a hydrodynamic oil film. Its inner race, the sleeve, is machined from unhardened seamless tubing and is press-fitted onto the shaft. The outer race is steel-backed babbitt, surrounded by a supply of Permawick which releases lubricant through a conventional window and channels within the babbitt.

Oil flow is a function of the temperature and rotative speed of the inner race. The bearing seems particularly suited to higher speeds—they ensure the formulation of a continuous oil film between the races. Recommended operating temperature range is from −25 to 200 F. Thrust washers and oil slingers are located at both ends of the bore. Oil is returned to the reservoir by the slingers.

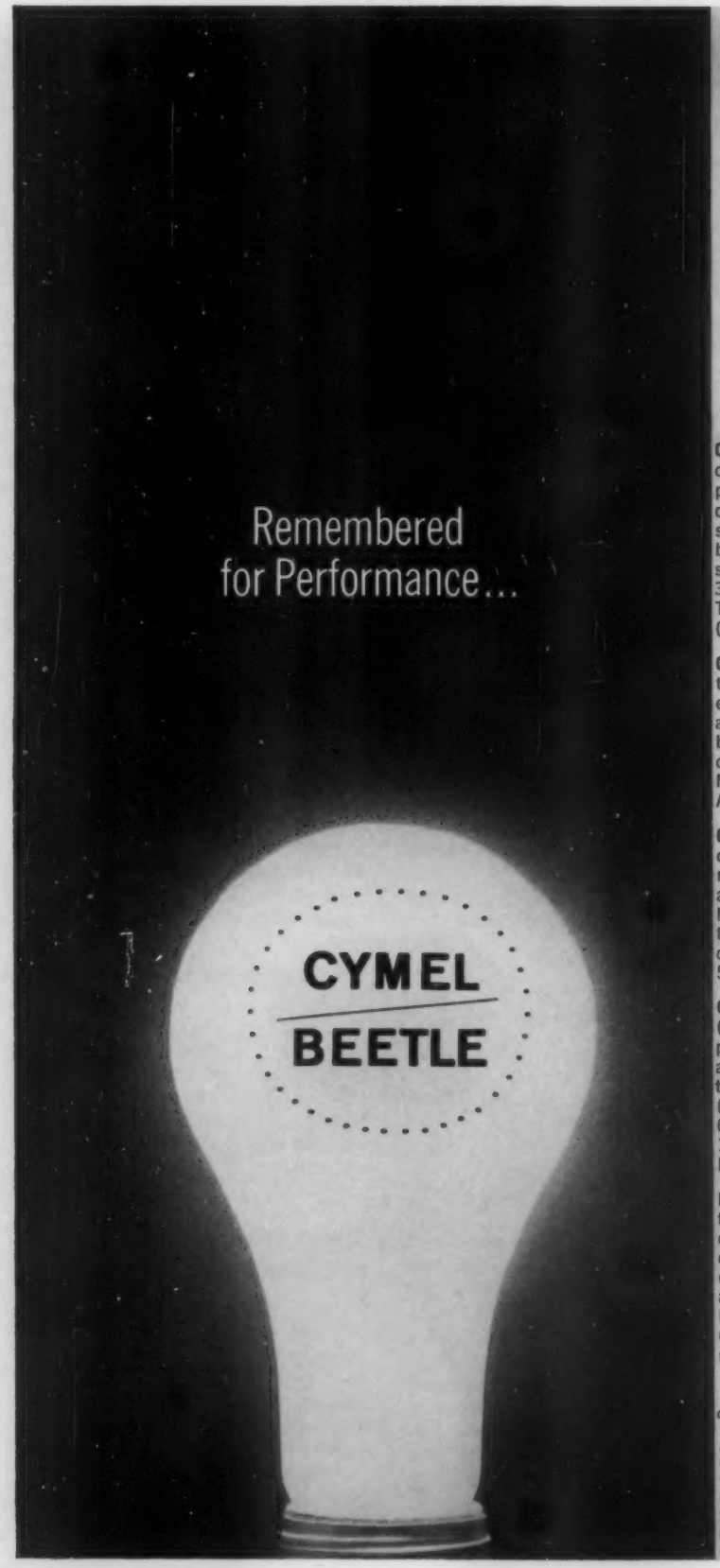
While the new bearings have the same OD of ballbearings of the same size, they are not interchangeable with them. Although the new bearings are not yet in production, price is expected to be the same as for 2-seal ballbearings. —Felix Giordano

Soviet Warns Its Technology to Speed Innovations

Moscow—Soviet planners, worried over the slowness with which new technology is reaching the production lines, have served notice that the present system must be altered to get more cooperation among different regions, industries, and enterprises.

Although the first quarter of 1960 shows an 11% rise over last year's

continued on page 20



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EXCELLENT ABRASION-RESISTANCE
CHEMICAL RESISTANCE

CYMEL 3135—3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

CYMEL 1500 (wood flour-filled)—CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

WRITE FOR COMPLETE TECHNICAL DATA.

CYANAMID

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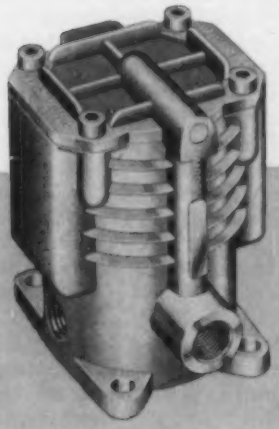
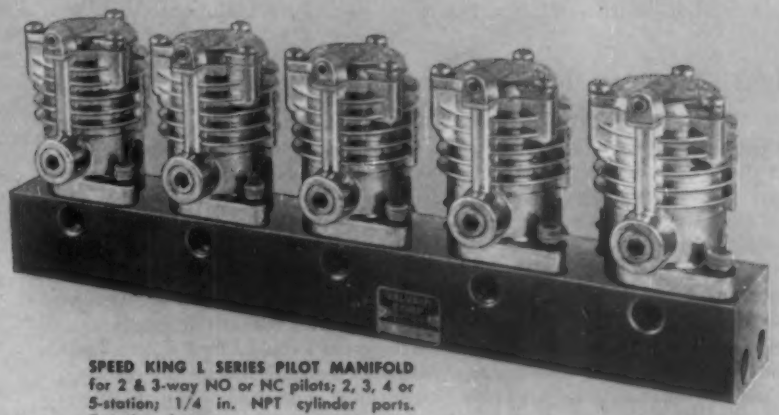
specify versatile...

SPEED KING®

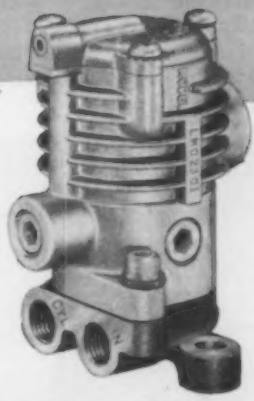
SOLENOID PILOTS



SPEED KING P SERIES PILOT 2 & 3-way NO & NC, 4-way; foot, sub-base or manifold mounting; 1/8 or 3/16 in. orifices. Foot mounting shown.



SPEED KING L SERIES PILOT MANIFOLD for 2 & 3-way NO or NC pilots; 2, 3, 4 or 5-station; 1/4 in. NPT cylinder ports. 5-station shown.



SPEED KING L SERIES PILOT 2 & 3-way NO & NC; foot, sub-base on manifold mounting; 1/16 to 1/8 in. orifices. Sub-base mounting shown.

Compact Valvair® SPEED KING pilots are ideal for control of small air or vacuum-operated devices including cylinders up to 3 in. bore, as well as for piloting larger valves. Featuring Valvair's flow-thru cooling design, they offer multi-million cycle dependability, with solenoid coils guaranteed against burn-out for the life of the valve. Choose from a full range of types, mounting styles and sizes; integral junction boxes (L Series only) and manual over-ride optional; coils for ac or dc, any voltage.

Solve your small unit control problems with SPEED KING solenoid pilots. Your Valvair or Bellows Field Engineer can recommend a size and type exactly suited to your requirements.

Bellows-Valvair

The Bellows Co. • Valvair Corp. Akron 9, Ohio

DIVISIONS OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

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CIRCLE 19 ON READER SERVICE CARD

continued from page 17

first quarter, an article in *Promyshlenno Ekonomicheskaya Gazeta*, by K. Petukhov, warns that innovations are lagging and this is interfering with the task of raising productivity. Petukhov, chief of the Soviet State Science Technical Committee, said "high-production machinery in some plants remains idle while work is being done by hand because no thought is given to the complete production cycle."

Several articles in recent weeks have criticized the lag in introducing new technology, but Petukhov is the highest ranking party official to scold so far. His warning indicates that, unless the problem is solved, Moscow is ready to reassert some of the authority relegated to regional planners in the 1957 decentralization.

Petukhov made it clear that his committee is prepared to take over supervision and to ensure cooperation between design groups and factories. He served notice that 1961's plans will differ from previous years. New plans must include a list of up-to-date processes to be introduced to production and a list of old processes and equipment to be abandoned. ■

Fastest Computers Now Ready for Marketing

NEW YORK—Two solid-state data-processing machines — one costing more than $10 million, the other priced at $55,500—were announced at the IBM annual stockholders meeting. The multimillion-dollar ones are similar to the STRETCH computer being built for the Atomic Energy Commission and classed as the world's fastest and most powerful. The other is the IBM 609, a general-purpose, punched-card electronic calculator to rent for $1175 per month.

According to IBM, STRETCH-class systems can complete more than 100 billion arithmetic operations a day, permitting extremely low unit costs in data processing. These units are ideal for IBM Teleprocessing applications in which the computer serves as the center of a network of office and plant input systems.

Internal storage is overlapped to quadruple the effective data flow. A typical system with six magnetic-core storage units could handle 1.5 million decimal digits. But with several storage units operating simultaneously, the system will accommodate as many as 2 million instructions and 2 million pieces of data per second.

A major feature is the "Look-Ahead" device that anticipates instruction and data requirements. It acts as a reservoir, storing up instructions and data to provide a continuous information stream.

The smaller data-processor is said to have a broad range of commercial and engineering applications. It can perform additions and subtractions in millionths, and multiplications and divisions in thousandths, of a second. No air conditioning or special power lines are required to operate the calculator, permitting significant savings.

Its storage is in the form of magnetic cores. The basic machine offers 240 positions of core storage, which can be increased to a maximum of 384 positions. Machine will read and punch cards at a basic rate of 200 cards per minute.

Another development revealed at the meeting is a computer tape system which will read and write information at a speed of 1.5 million letters or numbers per second. Called TRACTOR, it's fully automatic. Sealed cartridges containing reels of tape are stored within the unit. These cartridges are brought into positions automatically by the computer for reading and writing.

Thomas J. Watson, president of IBM, told the group that the company will deliver a total of 1100 small, medium and large solid-state devices by Dec, 1960. ■

STRETCH-CLASS COMPUTER nears completion at IBM's Poughkeepsie, NY plant. Custom-engineered systems similar to STRETCH, a model of which is seen in foreground, will be marketed to industry and government at prices upward of $10 million.

Logic 'Repairs' US Satellite 5½ Million Miles Away

LOS ANGELES—Because logical circuitry is most apt to malfunction in a logical way, a US engineer was able to correct a defect in the "telebit" system of Pioneer V, even though at the time the artificial planetoid was traveling through space some 5½ million miles away.

Robert E. Gottfried, engineer with Space Technology Laboratories here, along with a California colleague, had developed an 11-lb device which converts Pioneer V analog information into binary digits for transmission back to earth in the form of a stream of numbers. Function of the telebit is to assemble data on various radiation, temperature and other experiments within the satellite.

On April 15, Gottfried was informed by telemetry stations that tem-

perature reports from several components were inaccurate—did not jibe with previously recorded data.

Deciding that the trouble stemmed from within the satellite, Gottfried had to decide which of 1500 diodes, 1600 resistors, 1000 capacitors, or which of the connections was at fault. He set about tracing it down.

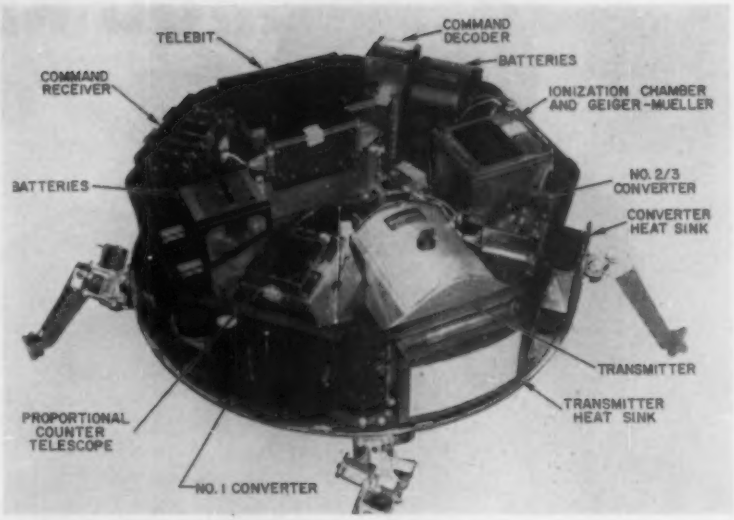
To convey values for 8 variables in sequence, the 10-bit word transmitted is made up of four identification bits and six information bits. The identification numbers appeared to be in order, so Gottfried began to check the information numbers in binary form to determine whether the flip-flops that make up the counter circuit were changing state. The problem had begun to look like an open diode circuit in the 6-stage counter.

In a counter of this type, each of the six stages can be in either of two states; changing from one to the other indicates the next higher count. A short in a diode circuit would "clamp" a flip-flop in one state, resulting in inability to change its transmitted value. An open diode—which proved to be the case—would merely result in an inability to transmit a certain group of numbers correctly.

Gottfried next derived a general formula for each of these possible groups of numbers, determining what numbers could not possibly be transmitted for each of the possible malfunctions. Comparison with data received indicated which of 26 possible diode circuits had opened. Having isolated the malfunction, Gottfried had no trouble devising a translation code to indicate the possible alternative value for each of the eight pieces of data. Correct one can be selected on the basis of prior information.

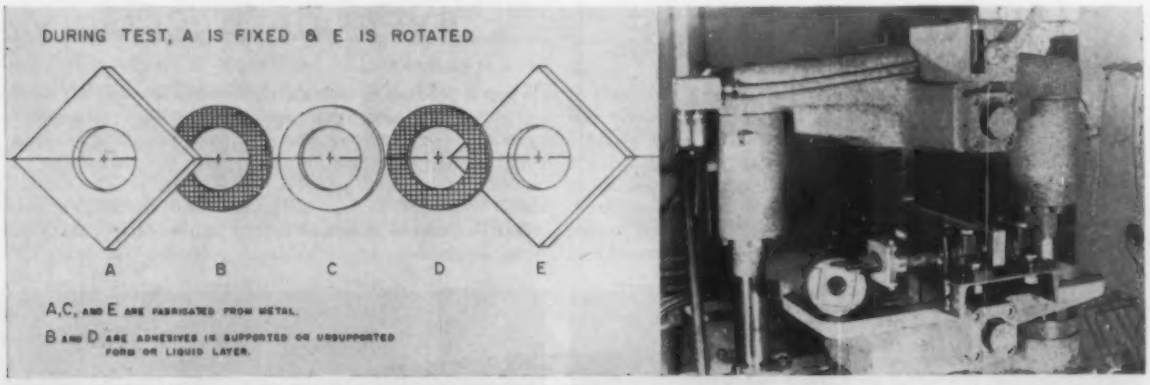
Such application of the translation code to accumulated information has been checked out, resulting in a "high degree of confidence that the determination of the fault is accurate."

—Jack Meyer, LA Bureau



INSTRUMENT PACKAGE of Pioneer V. Telebit stores, converts and monitors data from the experiments being made before supervising data transmission back to earth via telemetry.

New Adhesive Test Speeds Use of Data


DURING TEST, A IS FIXED & E IS ROTATED
A
B
C
D
E
A, C, AND E ARE FABRICATED FROM METAL.
B AND D ARE ADHESIVES IN SUPPORTED OR UNSUPPORTED FORM OR LIQUID LAYER.

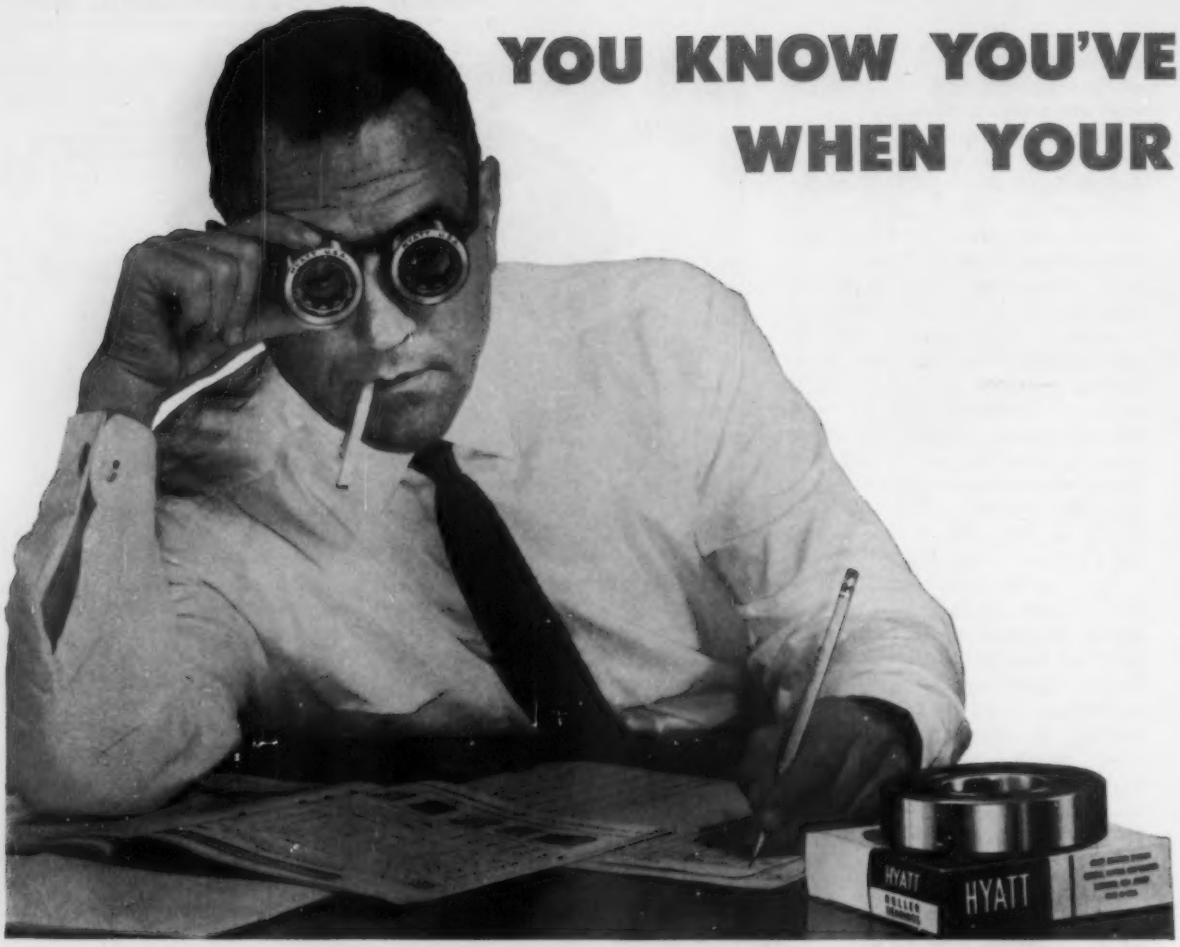
STRUCTURAL-ADHESIVE SHEAR-TESTING bonds a washer between two squares. Advantages include: elimination of adherend influence because of mechanical properties; immediate determination of true cohesive strength of the adhesive; direct values of adhesive failure; shear modulus is given by simple strain data; and simultaneous testing of adhesive-adherend systems. All this is obtained with mass-produced, accurate specimens costing slightly over $1 each.

SPECIMEN IS MOUNTED between a fixed and moving jaw, with the square faces of the specimen acting as drivers. Moving jaw is rotated by a lever-shaft system with force applied on the lever of the machine. Machine applies pressure to arm as table is raised. Lever distance to shaft center is kept constant by placing a hardened and ground pin on lever at point of loading. Combinations of adhesive systems in conjunction with dissimilar metals are easily tested and evaluated.

MAYNARD, MASS.—The bottleneck in the shear-testing of structural adhesives is being sidestepped by a new test configuration devised by the Metals Application Section of Raytheon's Maynard Laboratory. Present lap-shear-joint specimens require extensive testing and analysis to find the properties of the adhesive itself. New

continued on page 24

YOU KNOW YOU'VE WHEN YOUR

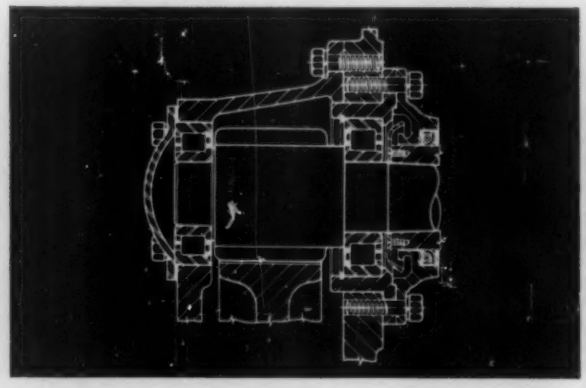


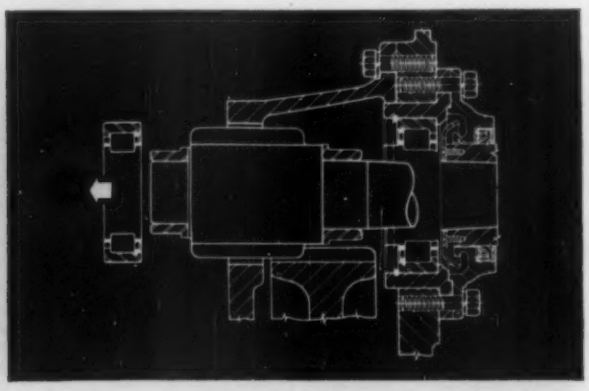
SIMPLIFY AND SAVE

A second look at the very same shaft shows how easy it is to "design in" a Hyatt bearing. It requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit. Rest assured, they'll never come loose because Hyatt Hy-Roll races are made from case-hardened, carburizing type steel. The hard outer case and tough ductile core permit heavier press fits without fear of cracking.

EXPEDITE ASSEMBLY

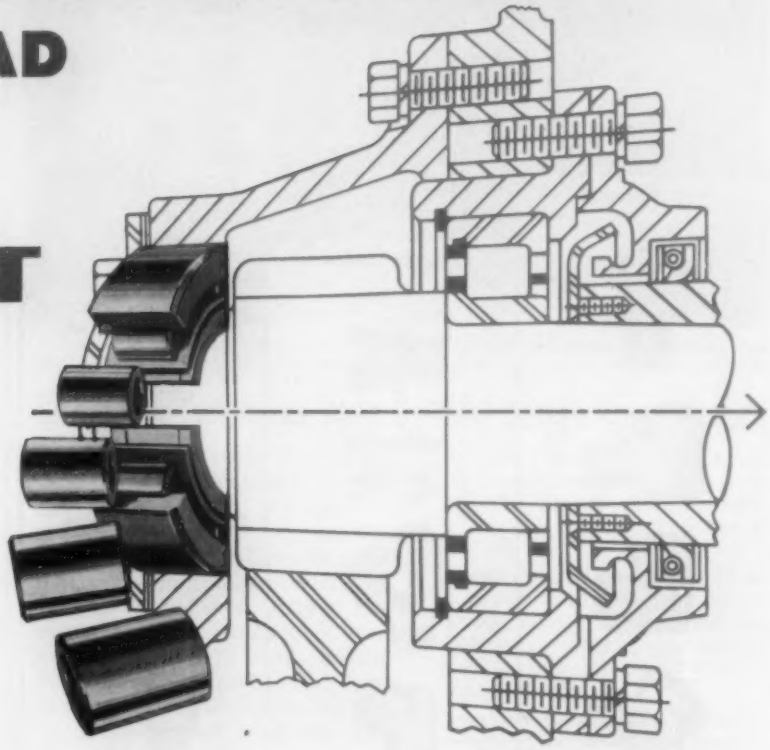
When a product is assembled, you can see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because Hyatt has made selective fitting unnecessary. Think of the time it saves!





PUT THE SHAFT IN ITS PLACE "SPECS" READ

HYATT



DO BOTH JOBS AT ONCE

Remember how versatile Hyatt Roller Bearings can be. Primarily, they're designed for the heaviest radial loads. But, with shouldered races, they'll also accommodate a considerable amount of thrust load . . . enough to provide adequate shaft location.

Here, for example, is a spur gear drive pinion on an opposed pair of R-YS type Hyatt Hy-Roll Bearings. Shoulders on the inner and outer races restrict lateral movement without sacrificing any of the high load carrying capacity inherent to cylindrical roller bearings. Thus, Hyatt gives you a bearing combination that combines high radial load carrying capacity with convenient shaft location.

You're assured smooth, trouble-free performance the minute you specify Hyatt Hy-Roll Bearings. For Hyatt quality is constantly checked and electronically controlled to insure that the last Hyatt Hy-Roll is every bit as accurate as the first.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the shaft or housing bore can be suitably hardened and ground.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt Sales Engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

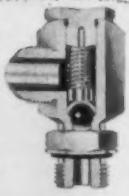
Simplify
Your Hydraulic Connections with ANCHOR®

- Prevents Hose Strains Caused by Twisting during Assembly
- Safer, More Positive, Leak-Proof Connections
- Easier Assembly in Confined Spaces
- Eliminates One or More Pipe Thread Joints

PIPE FITTINGS

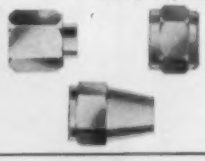
ADAPTER UNIONS

SAE STRAIGHT THREAD "O" RING FITTINGS



CHECK VALVE

TUBE NUTS



Andy Anchor says:

For complete specifications on these precision-made, space saving, trouble saving, hydraulic fittings, write today for Anchor's New Catalog No. 206

ANCHOR COUPLING CO. INC.

326 North Fourth St., Libertyville, Illinois
Branch Plants: Dallas, Texas, Plymouth, Mich.

continued from page 21

test configuration allows rapid and accurate recording of mechanical data. Recorded data can be used with proper stress analysis to allow more reliable calculation of structures without building a prototype.

Torsion test—used to find shear properties—consists of two bond joints, produced by adhering a washer between two squares. Holes, bored in the squares, keep all parts concentric in bonding and testing, by use of a single through shaft. Parts are made cheaply from sheetmetal, and machined in multiple layers with a minimum of alignment problems. Present specimens are of aluminum, stainless steel, magnesium, and combinations of the three.

Testing is done in a torsion jig—with power, rate, and load being indicated and controlled by a universal, hydraulic testing machine. Strain measurement is done directly between the two driving squares of the specimen, eliminating all errors in the system to that point. The only deflection not in the adhesive joints is in the washer, which can be easily calculated as a short hollow shaft.

Once the maximum pure shear stress is found, various treatments are applied to the specimen surfaces—corrosion-resistant coatings, chemical etches, and others. These yield coefficients that can be expressed as a function of the assumed pure shear stress.

The work yields a relative classification of many variables in one function of a quantitative value. For example, data obtained at different temperatures and other environmental conditions give direct mechanical properties of the adhesive-adherend, and stress analysis on design joints gives information as to the strain in the proposed joint or structure, permitting a proper adhesive-adherend system to be chosen. ■

British Machine-tool Recession Ends

LONDON—The annual review of metalworking machine-tool orders and deliveries by the Machine Tool Trades Association indicates that the recession in the industry is ending. During 1959, value of outstanding orders rose by 3% to $156.5 million. And provisional figures for January 1960 show a further 5% increases to $164.7 mil-

lion—about 8 months' production.

Deliveries have reacted more slowly to the quickening pace of economic expansion, but January figures reflected the trend, rising to $20 million, 15% higher than last year. ■

CBS Claims Advances in High-speed Visual Display

NEW YORK—The Columbia Broadcasting System has demonstrated here an all-solid-state device that electronically generates numbers, letters, or symbols, and then displays them on a cathode-ray tube. In such a system, electronic circuitry replaces type fonts or graphic originals. The words it displays can be permanently recorded by tying in with a photographic or electrostatic system.

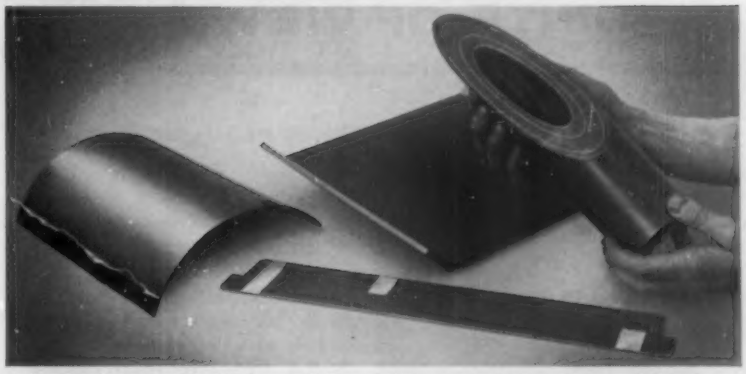
While noting that character generators are not absolutely new, CBS lab engineers believe that their equipment, known as VIDIAC, represents a substantial advance in the art. The quality of letters, they say, is high; the choice includes upper and lower case as well as symbols for aircraft, ships or missiles.

Speed of operation rivals that of advanced computers. A system of 150 different characters, each with 100 TV-picture elements, for example, can be displayed at the rate of 100,000 characters per sec. The engineers also developed circuitry for reproduction at 400,000 characters per sec; but at these speeds, although the characters are legible, they are not as sharp as CBS would like.

As for applications, CBS believes that, for the present, this equipment will primarily be tied in with man-machine systems, where the man needs to get information visually from the machine and return information to the machine. The first commercial unit, made for Thompson-Ramo-Wooldridge, will serve some such purpose in a military data-processing system. Eventually, the character generator may be tied in with electromechanical line printers for such jobs as addressing labels; or in translation systems, or possibly even adapted to proto-composition in the printing industry. CBS is also working on electronic circuitry to precisely control position of letters and symbols. The equipment could then apply in systems where position of symbols is important, such as displaying the position and direction of aircraft. ■

(ADVERTISEMENT)

Important facts to know about laminated plastics



A few Taylor composite laminates (left to right): copper-clad section; sandwiched copper component; Taylorite vulcanized fibre-clad part; laminated tube, copper inserts.

Composite Laminates Open Up New Design Opportunities

While the great variety of commercially available laminated plastics satisfy most electrical and mechanical requirements, there are applications that can benefit from the combination of properties provided by composite laminates. Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. These can be supplied as clad or as sandwiched materials. And they can be molded into many shapes to fit design requirements. Taylor is presently supplying to order the following composite laminates:

- **Copper and laminated plastics.** Clad for printed circuits and formed shapes. Sandwiched for special applications.
- **Taylorite® vulcanized fibre-clad laminates.** These combine the high strength of laminated plastics with the superior hot-arc-resistance of vulcanized fibre. They are being used in both high and low-voltage switchgear applications. Also in applications where the high impact strength of vulcanized fibre may be advantageous.
- **Rubber-clad laminates.** Almost any type of natural or synthetic rubber may be used as the cladding material. These laminates are widely used for condenser tops in wet condensers to protect the laminate against highly alkaline electrolytes. They also have application in any part where sealing or chemical resistance is needed.
- **Asbestos-clad laminates.** For applications where high heat- and arc-resistance are required.
- **Laminate-clad lead.** Lead sheets sandwiched between Grade XX paper-base laminates have been used for X-ray shields. The laminate provides strength and contributes to the high shielding properties of the lead.
- **Aluminum-clad laminates.** These have been used extensively for engraving stock. They also offer possibilities as printed-circuit material and as plate holders for X-ray machines.
- **Beryllium copper-clad laminates.** Beryllium copper is nonmagnetic and a good conductor—properties that give these laminates possibilities in many applications.
- **Stainless steel-clad laminates.** Applications where nonmagnetic properties are required. Also in certain corrosive environments where the resistance of stainless steel to attack is an asset.
- **Magnesium-clad laminates.** These laminates have been produced in 108-in.-long sheets for use as screens for X-ray operators. Weight was a factor.

Our design and production engineers are constantly developing new materials, new applications, and new procedures for fabricating laminated plastics. Our experience is yours for the asking. And if you have a problem requiring assistance or more information on composite laminates, write us. Also ask for your copy of Taylor's new guide to simplified selection of laminated plastics. Taylor Fibre Co., Norristown 39, Pa.

Taylor
LAMINATED PLASTICS VULCANIZED FIBRE

POINTS OF VIEW

THE QUESTION:

How Can an Engineer

Saul Poliak
Clapp & Poliak Inc
Show Management
New York, NY

"A humble and receptive attitude

. . . is so important. Go to an exposition or a conference in a spirit of calculated innocence. Resolutely put aside any inclination to assume that what you will see or hear may be 'the same old stuff.' The person who gets least out of such events (and, I suspect, puts least into his job) is the man who enters and leaves with the conviction that his store of knowledge is admirably complete and that no meeting or show is likely to teach him much of anything. A good deal that is said in any meeting is known and familiar. But it is a thorough egotist and a stupid one who can't learn much of value from an intelligent exchange of information and technique among competent men.

"And there is no exposition–particularly in a field whose technology moves so swiftly as that of design engineering–that fails to produce scores of products and applications that are new even to the supremely well-informed engineer. The riches are there abundantly. They elude the skeptic. They reward the man who listens, looks, and seeks them out."

"Use a trade show or technical conference . . .

to obtain new ideas that will enhance creativity. To do so most effectively, an engineer must carefully select the meetings to attend, and prepare in advance to capitalize on the most important offerings. 'He who would capture the wealth of the Indies must take the wealth of the Indies with him.' This dictates a study of the agenda or list of exhibitors and study of advance research into current work in the field or recent announcements by the exhibitors so that he can plan where best to seek out answers in his sphere of interests.

"When confronted with conflicts between equally attractive programs, he must be prepared to find an associate with whom to exchange notes immediately after the session so that he can follow up interesting leads before the experts depart. He will find it well to be alert to the experience and capabilities of other participants who may have done or may be familiar with other detailed work in his areas of particular interest. These working participants frequently have fresher information than the main speakers. Thus, it is well to make good use of the free time for discussions with his knowledgable peers.

"One helpful tool is a notebook for jotting down ideas and names while they are fresh. It is well to reserve a scheduled amount of time for general looking or technical discussion in order to uncover the unanticipated ideas that sometimes turn out to be the most significant results of the occasion. Immediately upon returning from the event, the engineer must make it a point to record his significant impressions and ideas for future use."

Robert F Elder
President
Plax Corp
Hartford, Conn
(Chairman, 9th National Plastics Exposition)

Get the Most From a Trade Show or Conference?

Dr Arnold M Small
Mgr, Product Effectiveness Lab
Hughes Ground Systems Group
Fullerton, Calif

"The number-one requirement

. . . is that steps be taken to permit the engineer who attends a technical meeting to have some preview of what he's 'in for.' Already, many professional societies are providing preprints of papers; the important thing is that engineers get and read these and then carry them to the meeting. When it is made known in advance that the paper will not be read as such by the author, those who plan to attend the meeting know that they will have to learn in advance what he's talking about. That old saying, 'You only get out what you put in' is very true, and this system makes the attendee put something into the meeting. The speaker then talks **to** the paper rather than from it. Frequently, he will take some of the highlights and present them as a quick synopsis to set the stage for discussion. A good 'gimmick' is to refer to illustrations in the preprint instead of projecting slides. This does away with the distraction caused by having to project slides, overcomes the fact that there are usually some people who can't read even the best-made slides, and–most important of all–gets the audience to actively use the preprint.

"Then, you have to consider the importance of the moderator. He, too, should have studied the papers in advance so that he can do the right sort of job of introducing the speakers and tying the papers together. It is up to the moderator to generate and direct fruitful discussion; and he can help the participants greatly by summarizing. A good moderator works very much like a good editor; he picks out weak points and leads to them with questions. Also, he is generally prepared to make some constructive contributions from his own experience.

"You can't just be a sponge. Notice, I didn't say you shouldn't; but my experience indicates that you have to 'squirt back' a little. Programs themselves have to be organized in a way that makes it possible for the engineers who attend to get something out of them. Societies have started to differentiate between 'tutorial' sessions–where the newcomer has a chance to benefit from some of the experience of the oldtimer–and sessions where the latest research and advances are reported."

"There are three ways . . .

for a company to benefit from a trade show or conference. The first, and obvious one, is to send the most qualified, proficient engineer. He can see beyond the end of his nose without management direction–since he knows well before packing his bags what he will be looking for. He, for example, is able to detect design trends in equipment that does or could utilize his firm's products–and return with ideas as to what his firm must do in the future to anticipate these trends.

"Second, it is necessary to expose the younger, less experienced engineer to the show or conference. He, of course, must be given maximum direction to prevent aimless wandering. The best way to do this is to work out definite assignments with him–seeking solutions to certain problems not only in his own sphere of work, but also in related activities. He should be well coached to dig out every bit of information available on components, materials, processes, etc., with which he should be concerned.

"Third, a company should send an engineer who is relatively inexperienced in solving a certain set of engineering problems–because he is free of past prejudices and can look for fresh ideas with an open mind. This, of course, is a 'long shot' approach–but with proper guidance he can look for every conceivable method of approaching certain problems, and also search for entirely new industries wherein his firm's products can find buyers."

Donald M Strathearn
Vice-president
Controls Company of America
Schiller Park, Ill

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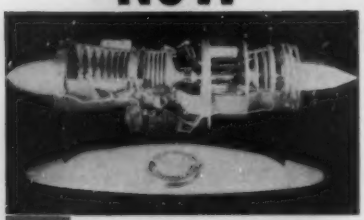

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READER TO EDITOR

Remedy for the "Engineer Shortage"

To the Editor:

During and since World War II, much has been written about the shortage of engineers. In almost every case it has been stressed that there is a shortage whereas it is actually a case of poor usage. In your Mar 14 issue, p 55, G. Ross Henninger writes that what is required are engineering technicians. Engineering technicians set up with a totally separate identity, as he suggests, will only complicate the problem rather than correct it.

In recent years, in a great many companies, it has become very popular to divide Drafting and Engineering into separate units, with very little or poor liaison between them. These groups have become very jealous of their prerogatives and, instead of increasing the efficiency of the over-all department, have developed new problems that have had a marked affect on the end product. Setting up still another species called the engineering technician will develop a third camp and, instead of improving the functioning of the engineering department as a whole, will only serve to complicate the situation.

This problem can only be eliminated by some good common horse-sense on the part of the engineering colleges and of the Management. Yesterday the engineering graduate was told, "Don't go on the board;" today he is told, "Go into sales; that's where the money and glamor are." At this rate, pretty soon we will have all our engineers on the road with nothing to sell.

The following is a solution to the problem:

1. Have engineering graduates who will follow all phases of applied science spend from one year to eighteen months on the board or in some other endeavor that brings them into close association with the shop—at first under close supervision and then where more and more individual initiative can be exercised.
2. After the period of indoctrination, the engineer should be ready to go into design, testing, preliminary development, etc. This period should last until the man has a total of five year's actual experience. At this time the man would have earned the title of engineer—and not before.
3. With this much experience behind him, a man should now be qualified to go into almost any of the engineering functions — development, experimenting, production, research, sales or service. Each of the above-mentioned engineering functions, with the exception of sales and service, has the need for drafting, design and technical effort, and the engineering graduate can progress through any one of these to gain his practical experience.

This program will weld engineering back into a whole and eliminate the factionalism and friction that now occur. It

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will make it possible for a man to develop logically, on the basis of his ability, and eliminate round pegs in square holes. It will make an engineering department a department of engineers instead of a lot of chiefs and very few Indians. It will eliminate the "shortage of engineers" by keeping more men in engineering, and eliminate the frustrations that now force men with technical training and background into other endeavors.

In addition to solving the engineering shortage, this program will have two side-effects:

1. It will help eliminate some of the labor problems within the engineering department by the dissolution of rigid boundaries among the various functions within the department.
2. The engineering department will be better qualified and, as a result, will develop and design a better and cheaper product.

—H Alan Duguid
Huntington Industries
Shelton, Conn

Empirical Equation to Save Time

To the Editor:

Just recently I ran across this formula in my desk at home while rearranging my files. If it were published it might increase engineering-department efficiency by making a lot of nonsense inherent in these organizations ridiculous.

$$W=\left[\frac{\left(\frac{E+K}{P}\right)^{1.35}\times D^2\times(h+T)^3\times\left(\frac{G+C_t}{33000}\right)^{.071}}{\left(\frac{B-e}{L}\right)^{0.002}\times\left(\frac{Fxt}{H_a}\right)+\left[(\omega+A)^3\times S\right]^{\frac{Z+6}{2}}}\right]^{X^4}\times(H+\operatorname{Tan}\phi)$$

Where:

W = Work accomplished
A = Arguments had
B = Butches made
C_t = Cigarettes smoked
D = Determination
E = Experience
F = Frustration (general)
G = Gum chewed
H = Hours worked
H_a = Headaches engendered
K = Know-how
L = Lost motion in system
ϕ = Angle of direction started for
P = Persistance
e = Errors made
h = Sense of humor
ω = Waiting time
x = General bafflement
Z = Zaniness (general)
S = System battles
T = Tolerance
t = Tizzies had

—Ashley C Hewitt
Pasadena, Calif

Sameness in Design

To the Editor:

In your article, "Too Much Sameness—Pitfall of Industrial Design," Feb 22, p 24, what must be concluded? Is not this sameness a function of the "formula" approach followed by "method" actors and "handbook" engineers? May we look to the origins of all these accused con-

continued on page 30

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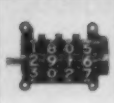

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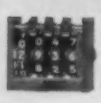

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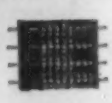

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formists and see if their education and subsequent development is steeped in any grand philosophy? No! The grinding out of a soap opera act, the hacking out of eight hours of detail drawings or the gimmicked rendering of a "winning" industrial design are hardly acompanied by a crusade.

Frankly, this article touches upon the fact that, with his traditional methods, the classic industrial designer can no longer really contribute effectively. A pox on those whose avoidance of technical progress precludes their assuming a more comprehensive contribution in a valid product-development sequence.

—E Paul Meylan
Los Angeles, Calif

COMING EVENTS

MAY

9-13 . . . . Society of Photographic Scientists and Engineers, 1960 Annual Conference, Miramar Hotel, Los Angeles

9-13 . . . . American Society for Metals, Southwestern Metal Show, State Fair Park, Dallas

10-12 . . . . American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn, Western Electronic Manufacturers Assn—Electronic Components Conference, Washington, DC

18-20 . . . . Society for Experimental Stress Analysis, Stress Analysis in Propulsion Systems, Indianapolis

23-26 . . . . American Society of Mechanical Engineers, Design Engineering Conference, New York Coliseum, NYC

23-26 . . . . Clapp & Poliak, Design Engineering Show, New York Coliseum, NYC

23-26 . . . . American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of Aeronautical Sciences—National Telemetering Conference, Marimar Hotel, Santa Monica, Calif

JUNE

10-26 . . . . British Exhibition, New York Coliseum, NYC

13-15 . . . . Metal Powder Industries Federation and American Institute of Mining, Metallurgical & Petroleum Engineers, jointly sponsoring International Powder Metallurgy Conference, Hotel Biltmore, NYC

19-21 . . . . Alloy Casting Institute, Annual Meeting, The Homestead, Hot Springs, Va

Nature's Tiny Flashlight. There's more to the surprisingly bright flashes of the firefly (*Lampridae*) than the body chemicals which it burns. In addition, a clear, curved section of the insect's skin acts as a magnifying lens and a layer of crystals as a reflector.

Miniature Angle Counter. Moving tape on this counter used in aircraft (approx. 3½" long) shows horizontal angular deviation from pre-set point. MPB bearings on key shafts help keep torque at approximately 0.1 ounce-inch at temperatures from −55°C to +125°C!

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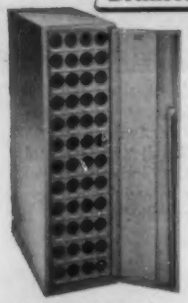

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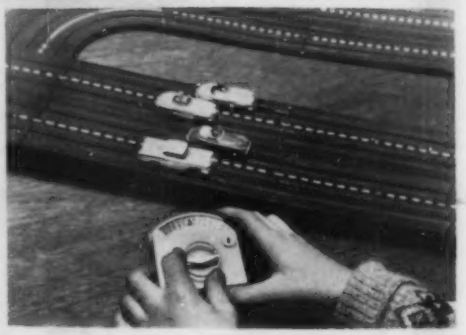

Model motoring will supplant model railroading in the hobby room if Aurora Plastics has its way. Aurora is readying, for midyear introduction, a complete "road show" in HO scale with highways replacing tracks, and electric-powered autos instead of trains. Road sections can be arranged to form freeways, cross-overs, and cloverleafs.

Key to the whole system, says Aurora, is a brand-new, vibrating-armature motor "smaller than a dime, thick as two nickels, and containing only 3 moving parts."

The autos are powered by a standard 12-24 volt ac power source or model-railroad dc HO ¾-amp transformer, one such unit handling as many as 10 cars at scale speeds up to 150 mph. The cars are designed for rear-wheel drive, have a chassis 1⅞ in. long, and are made up of about 30 die-cast parts.

Starter sets will be priced at $10.95, with a "deluxe" set at $16.95 and additional accessories to be made available later.

DuPont wooing boaters

An aerosol spray to dry out damp ignition systems and prevent corrosion . . . fuel and oil additives to improve engine performance . . . water repellents and protective coatings for canvas . . . an assortment of cellulose sponges for cleaning and bailing—these will lead off a parade of products being planned by DuPont especially for boating enthusiasts. To be known as the "7 Seas" line (to match DuPont's "Number 7" automotive products), it's one more indication of the tremendous market that has been created in recent years by water-loving Americans.

Portable heart-throb ready for use

Transistorized, battery-powered, and weighing less than 1½ lb, a new "pocket" cardiac resuscitator is ready to revive drug and anaesthesia victims. Stimulation rate can be varied from 50 to 200/min., output from 5 to 120 ma at 1000 ohms.

The designers have even considered the health of the unit itself. The plastic case, they say, keeps out moisture and allows for damp cleaning with alcohol; the battery can be recharged with a small unit that operates from a standard circuit. Metronic Inc, Minneapolis 18, makes it. —ARG

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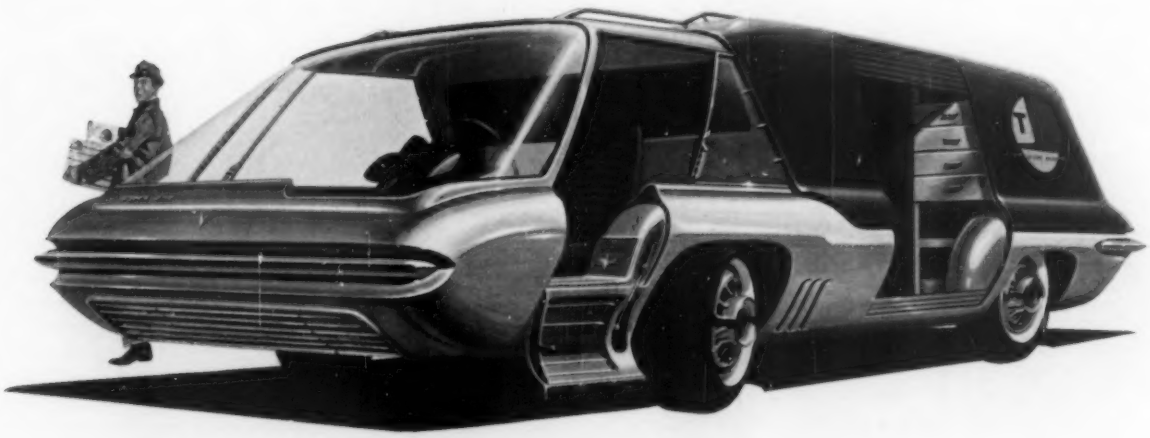

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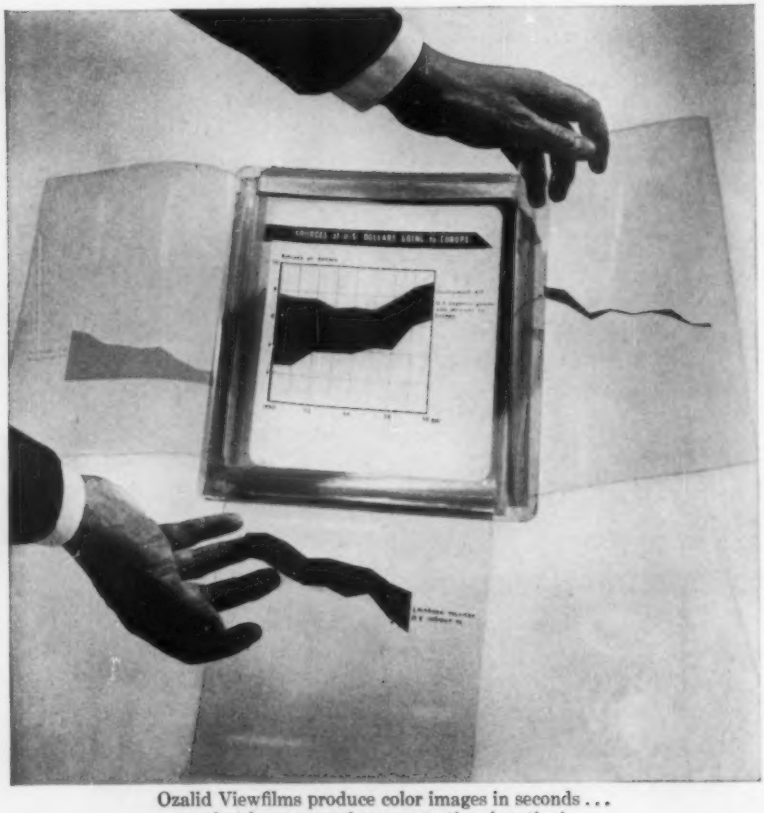

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Next, run the master through your Ozalid machine together with an Ozalid Viewfilm of the proper color. Want to add more material in a different color? Just prepare another master, select a different colored film, and run them as you did the first pair. When you're all through, overlay the films in sequence and tape them into register. Your result is a composite color chart that's very dramatic . . . very convincing!

This is just one illustration to start your mental salivary glands working. We are sure that you can find uses we haven't even dreamed of, once you get going. And if you discover any new applications for this best of all possible color worlds, tell us about them so we can spread the good news to others.

When it comes to cost estimating . . .

. . . there's nothing like a handy white-printer to cut preparation time of cost estimates, according to the Stackpole Carbon Company, St. Mary's, Pa. The company's Supervisor of Cost Estimating has just written us a letter on the subject which we pass on to you verbatim. "Our estimates are made in pencil on printed translucent vellum in pad form. These are reproduced on specially cut and punched Ozalid copy paper. Originals carry only basic information that has to remain constant. And from the originals we produce duplicate originals on Ozalid sepia line intermediate paper (#402 IT) as required, and these are used until the basic information is obsolete. To revise a cost, it is only necessary to add current rates and extend. With this simple Ozalid method we have eliminated typing, proofreading, and copying errors."

The Supervisor goes on to say that Stackpole uses Ozalid copying in many other areas of its business because of convenience and economy. Perhaps we'll be able to tell you about these uses in a future *Newsletter*.

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Speed up your production? Of course! But that's only the beginning. Look at it this way. One Printmaster 1000® working at a usable 100 feet per minute matches the output of several smaller, slower machines *but takes up less valuable floor space while handling widths up to 54 inches!* You save on production time and costs due to higher working speeds! And the Printmaster 1000 is probably the toughest, most durable unit ever produced. This means even greater savings in downtime and service charges. Our first recommendation for any shop having heavy work loads is this 100-foot champ . . . the Printmaster 1000.

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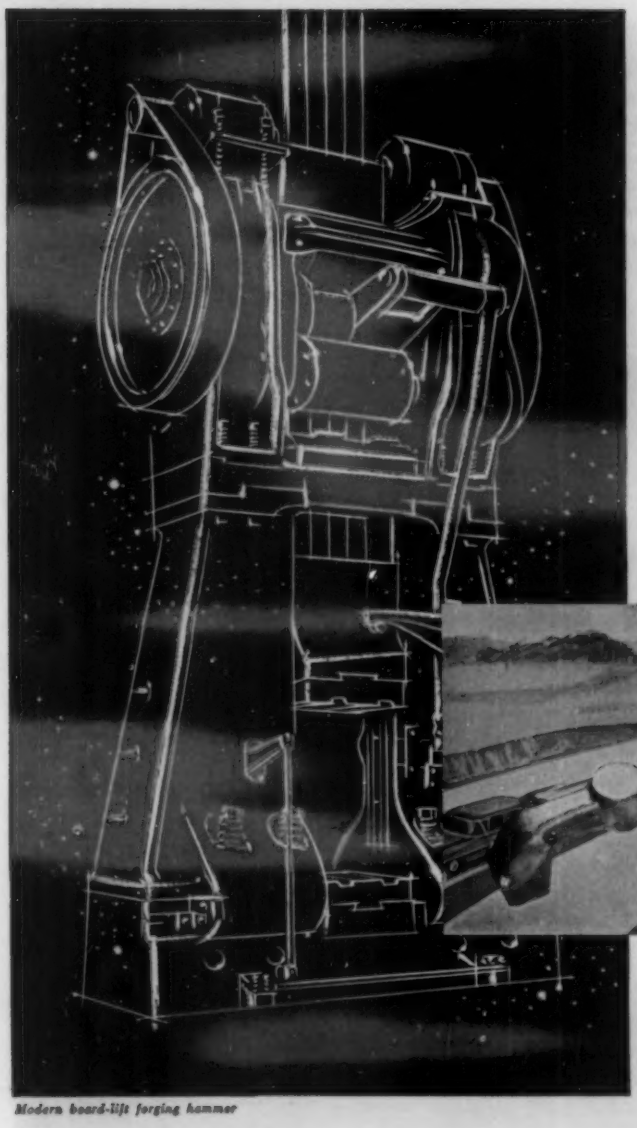
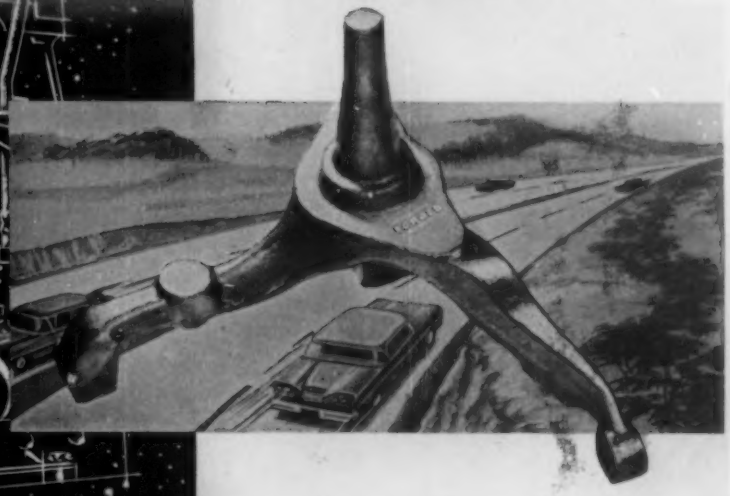


SHOCK-STRENGTH of steering spindle soars by designing it to be forged



Modern board-lift forging hammer

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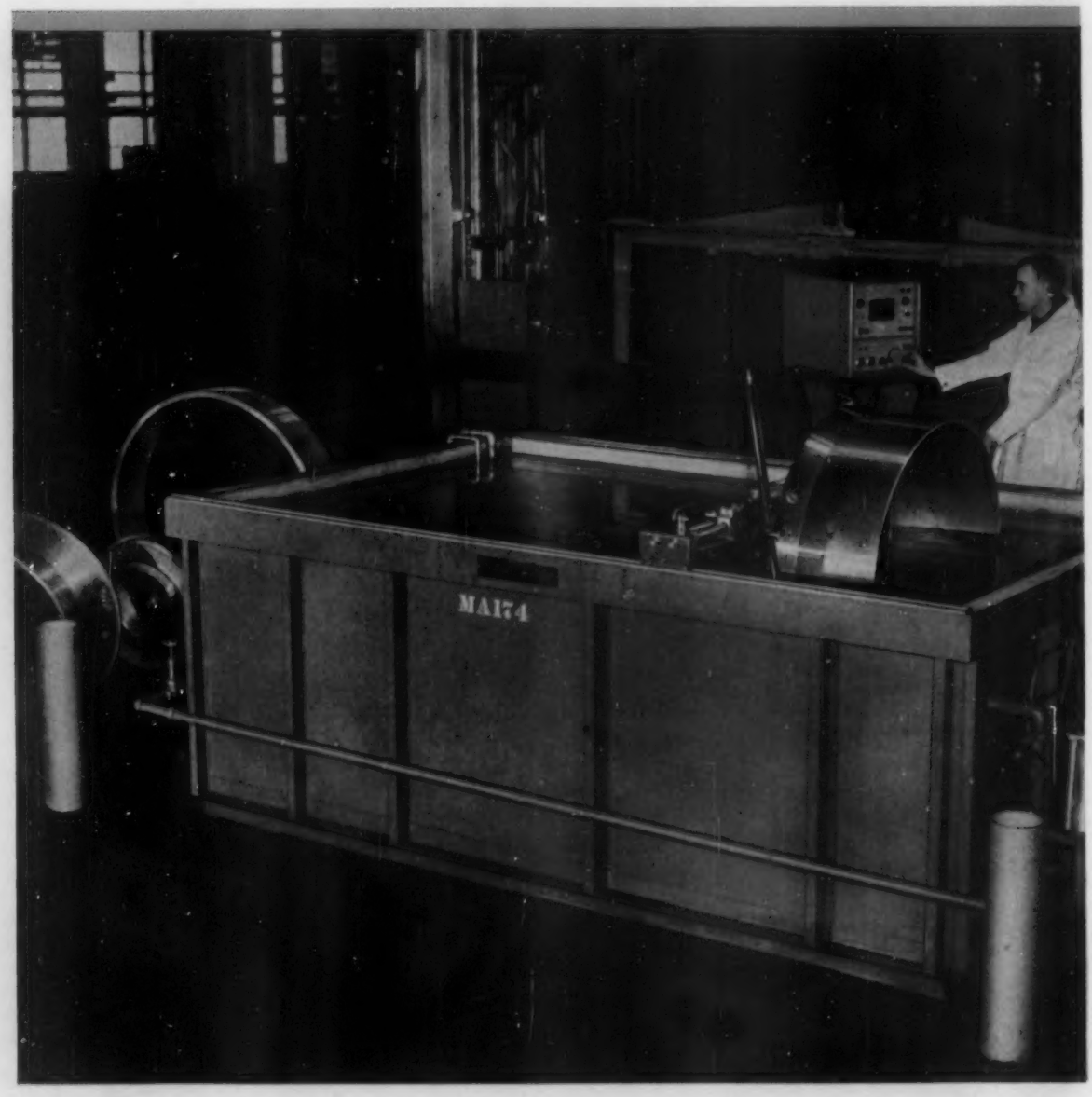

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PRODUCT ENGINEERING **HORIZONS**

May 9, 1960

Not So Fast, **ABERNATHY!**

The story is told of a Navy commander at sea to whom "Sparks" brought a message: "Inform Seaman Brown, R.C., that his mother has just died. Extend Navy condolences." The commander turned to his bos'n, a beetle-browed character, and said, "Bos'n, please inform Seaman Brown, and add my sympathies." The bos'n turned to the squawker and intoned: "Now hear this, Seaman Brown, R.C. Your mother has died, and the Navy and the Captain are sorry. Carry on."

The commander, properly irate, chewed out a mystified bos'n. When a month or so later, a similar message was received regarding Seaman Abernathy, N.R., the bos'n himself brought the message with the request that he be permitted to do the informing. He had, he said, given the matter serious thought. The commander reluctantly agreed.

Whereat the bos'n swung to the squawker and announced: "All enlisted men report to the after deck." When they had assembled, the bos'n paced back and forth in front of them for a turn or two, then swung abruptly on them and said: "All seamen with living mothers take one step forward—not so fast there, Abernathy!"

We're reminded of this yarn by the current worry that not enough of our nation's youth is turning to engineering as a career. What about the factors that militate against it? The greater current popularity of the word "science" is only one factor.

Granted that the student adviser in a high school rates third to parents and preferred teachers in influencing students' choice of college and career, who has ever heard of an engineer as a student adviser? And how many engineers are high-school teachers? How many non-engineer fathers are likely to visualize engineer sons? To top all that, better than half of each graduating class is eliminated at the start—they're girls. Not to belabor the point, what does a technically gifted girl do? She's no more popular in most engineering schools now than she was 30 years ago. Most scholarships exclude her; many technical colleges do. Yet, chief engineers tell me that female engineers are doing good work—in the jobs they're permitted to hold. And in the USSR. . . .

But that isn't the only point to be made here. The typical high-school student gets one year of science—usually biology—and no engineering. Perhaps he has physics and chemistry, but certainly no emphasis on either of these or on math—unless he creates the emphasis. He has no one around him suggesting engineering as a career, no nearby adults who exemplify the successful engineer.

There is one organization, however, that works in this direction—the engineering equivalent of the high-school science club. It's called JETS—Junior Engineering Technical Society, and has 750 chapters in high schools of 45 states. Some 15,000 students are being served currently. In 1959, 88% of the members of these clubs went on to college, 64% as engineering students. *Where it exists,* the organization is doing good work.

Those three words are the problem. In industrial areas, local industries sponsor clubs, providing an engineering adviser and assisting otherwise. Some state areas are coordinated by state technical universities or by professional societies. And most of the financial support comes from industry, the rest a grant from National Science Foundation.

Here is an organization motivating and guiding students to select content courses, encouraging good scholarship and top performance in high schools. It provides trips and work projects.

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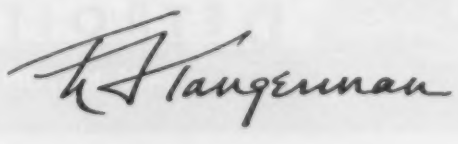

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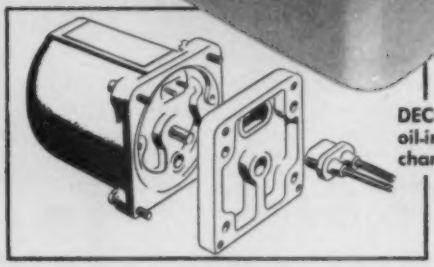

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PNEUMATICS SIMULATES ELECTRONICS

Previous articles in these pages have described the basic design of pneumatic devices based on electrical analogies. Now for the first time, using the pneumatic thyratron as an example, here is a dimensional analysis of all the essential units—potential, flow, power, resistance, capacitance—needed in actual applications.

PHILLIP M CONNAUGHT, *project engineer*
Eastern Research Center Div
Robertshaw-Fulton Controls Co
King of Prussia, Penna

It is useful to turn to an analogy when solving fluid-control problems that have complicated circuits. This explains the value of considering the flow of air in terms of the flow of electricity. But in comparing these two "fluids," caution is needed—they are not entirely analogous.

Air is a real fluid, electricity is a hypothetical one. Air is compressible, has varying viscosity; but electric current —a flow of electrons—is noncompressible, has no viscosity. Airflow obeys laws similar to those of electricity, but only if temperature and pressure changes are not too extreme.

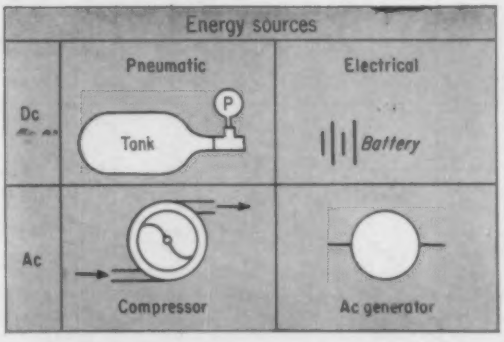
However, designers of air circuits can learn much from designs of similar electrical circuits now in use, if the basics are known and limitations observed.

WHAT ARE THE UNITS

Air and electricity are not equivalents, but the units table, below) are similar. By choosing proper dimensions of each, analogous equations can be derived.

ANALOGOUS UNITS

Pneumatic	Electrical
Pressure, psi	Potential, volts
Flow, moles/min.	Current, amps
Power, in.-lb/min.	Power, watts
Resistance, psi per cu in./min.	Resistance, ohms
Capacitance, moles/psi	Capacitance, farads



Pressure—the pneumatic unit easiest to measure—has its electrical counterpart in potential. A pressure gage or manometer can be considered a pneumatic voltmeter.

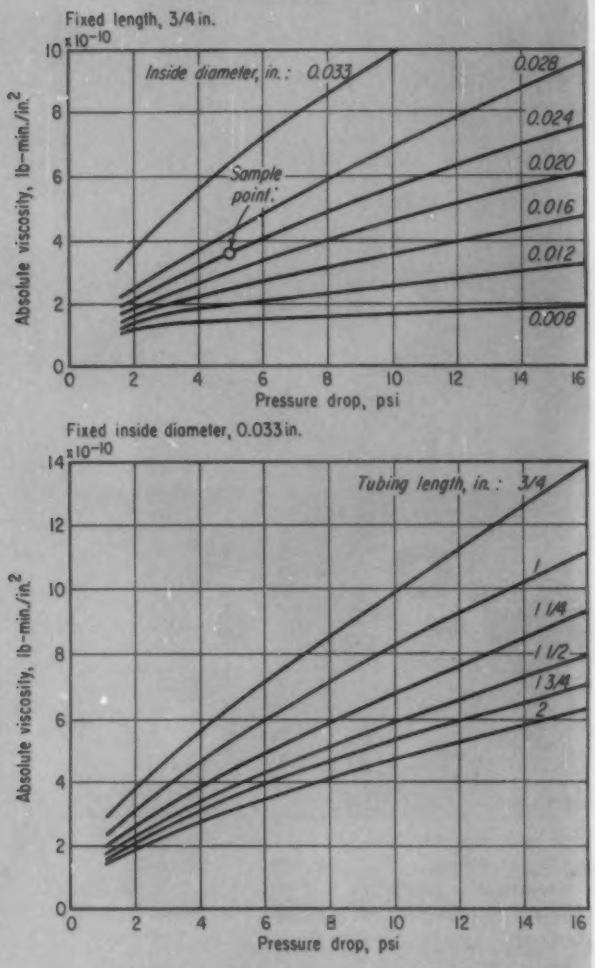
Flow of air is analogous to electrical current if the quantity of air molecules passing a given point is selected as the basis for measurement. Flow of air, in moles per minute, is analogous to electrical current, in coulombs per second. One mole at standard conditions of pressure and temperature equals 1.367×10^3 cu in.

Mole units, however, are awkward to work with in fluid-flow calculations, and should be converted to cubic inches. Use the ideal-gas relationship $V = NMT/P$ where N is the number of moles, P is pressure, V is volume, T is absolute temperature, and M is the gas constant whose value depends on the units chosen for the other quantities.

continued, next page

REPRINTED—Circle P51, inside back cover

Viscosity of air flowing in capillaries
(discharging to atmosphere)



AIR VISCOSITY does not remain constant with changes in pressure; therefore pneumatic resistance—a function of viscosity—will be different for each value of pressure drop. Increasing capillary length will reduce this resistance variation with pressure (obeying Ohm's law better) but the flows may become too small to use. Small inside diameters —less than 0.02 in.—give best results. Equation for graph: $H = 0.0245 \times d^4 \times \Delta P/(L \times Q)$ where H is absolute viscosity, $lb_{force} \times min./in.^2$, d is inside dia, in., ΔP is pressure drop, psi (atmospheric exhaust), L is tube length, in., and Q is volume flow cu in./min. Typical test data: $d = 0.024$ in., $\Delta P = 5$ psi, $L = 0.75$ in., $Q = 150$ cu in./min., $H = 0.0245 \times (0.024)^4 \times 5/(0.75 \times 150) = 3.62 \times 10^{-10}$.

Pneumatic power, in.-lb/min., is proportional to the product of flow, cu in./min., and pressure potential, psi. Electrical power, w, can also be expressed in in.-lb/min, by first converting watts to hp.

Resistance to flow of air (assuming constant absolute viscosity) can be expressed in this pneumatic version of Ohm's law: $R = \Delta P/Q$, where R is resistance, psi per cu in./min.; ΔP is pressure drop, psi; and Q is flow, cu in./min. The electrical version is $R = E/I$, with R in ohms, E in volts, I in amps.

But actual air viscosity varies with pressure, and no pneumatic-resistance element as simple as a capillary tube or orifice will obey Ohm's law. Fortunately, variations occurring in one part of a pneumatic circuit also occur in other parts, and the over-all operation may still remain in balance. If constant pneumatic resistance is mandatory, pneumatic amplifiers can be designed to give it—but they are complicated. A better answer is to accept the nonlinearity of capillary tubing or orifices, and calculate or measure effective resistance $R = \Delta P/Q$ for each set of conditions.

Note that the variables determining resistance R in the pneumatic Ohm's law are the same that determine absolute viscosity H in this well-known Poiseuille relationship for laminar flow of fluids through pipe: $\Delta P = (\text{constant}) \times H \times Q \times (L/d^4)$, where Q is volume flow, L is tube length, d is inside diameter. By rearranging terms and letting L and d be constants (true for a given restriction), viscosity H is proportional to ratio $\Delta P/Q$ which has units of resistance.

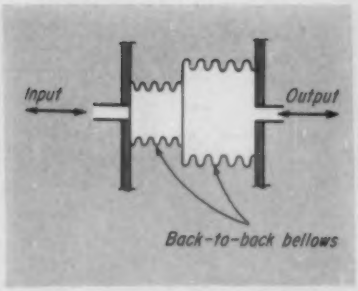
The similarity is not surprising—viscosity is the cause for pressure drop when flow is laminar. Plotted values for viscosity H (charts at left) can be converted to resistance R by multiplying by 40.8 (L/d^4).

Pneumatic capacitance—dependent on line, tank and device volumes—is usually extremely large when compared with values typical in electrical circuits. Therefore the pneumatic unit chosen is the megafarad—one million farads—which is many orders of magnitude greater than its electrical counterpart, the microfarad. Response of a pneumatic circuit is many times slower than that for electrical circuits because the relative capacitance is so much larger.

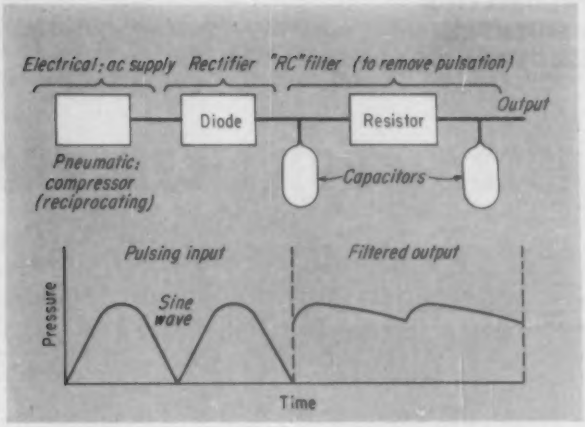
Units of pneumatic capacitance, $C = N/P$, are moles/psi, which can be converted to more practical cu in./psi units using the ideal-gas relationship, $PV = NMT$. For N, substitute its equivalent PV/MT, giving $C = V/MT$. Temperature may be assumed constant for most low-energy pneumatic circuits discussed here, and C therefore depends on volume alone. A one-farad pneumatic capacitor will have a volume of 7.34×10^{-8} cu in., based on room temperature. A one-megafarad capacitor will have a volume of 7.34×10^{8} cu in. under the same conditions.

PRACTICAL APPLICATIONS

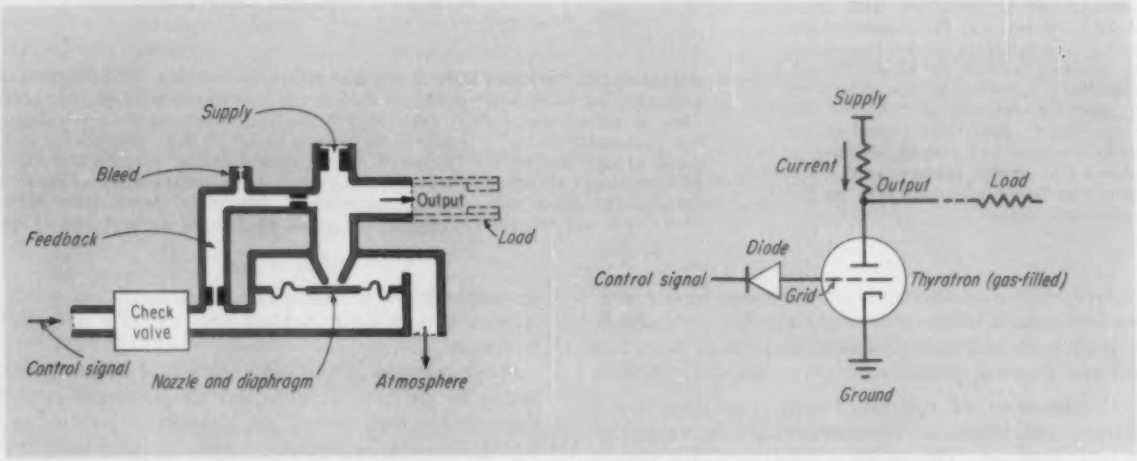
A recent article by H. S. Kachline (a colleague of the author), entitled "Pneumatic vs Electrical Control Elements," (*PE*—Apr 4, p 52) describes simple pneumatic resistors, capacitors, rheostats, diodes and triodes that have actually been built and proved practical. There are, of course, many other elements needed before a complete pneumatic circuit can be built. Here are a few of them:



PNEUMATIC TRANSFORMER, a pair of bellows back-to-back, is operated by ac current—as is an electrical transformer. Energy input equals energy output. Pressure × area of small bellows must equal pressure × area of large to maintain energy balance (assuming negligible spring gradients) because travel of each is same. Transformer ratio is determined by ratio of effective areas.



SMOOTH OUTPUT of rectified current is possible even if compressor is reciprocating type because resistor and capacitors "filter out" pressure variations; diode (air checkvalve) prevents back flow.



THE ELECTRICAL THYRATRON has its counterpart in the analogous pneumatic device. Both give output when a control signal is applied, but there is no intermediate or partial-output state—it is either on or off. In electrical version, the value of control "grid" signal required to trigger (fire) the tube depends on supply (plate) voltage. Expressed differently: for fixed grid signal, firing point depends on value of supply voltage. Firing time is extremely rapid, but turning off the thyratron takes much longer. A pulse control signal, or a continuous one will fire it, but once fired it can be shut off only by applying a large negative control signal, or by interrupting the "plate" supply. Same holds true for pneumatic version, but pressure is used instead of voltage.

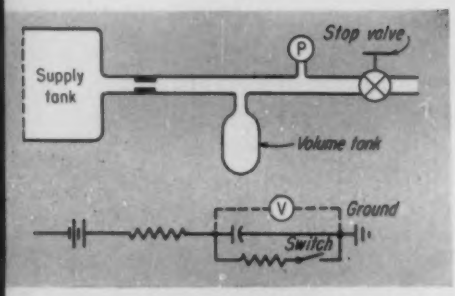
Energy sources—air tanks and compressors, analogous to electrical batteries and generators—are the first requirement for any circuit. Airflow can be constant (dc), alternating (ac), or pulsating (pulsating dc). A practical limit for frequency in an "alternating" air circuit is about 20 cps because many of the regulators and amplifiers will respond no faster. However, special pneumatic elements such as the fluid-jet amplifier recently developed by the Army (*PE—March 14, p 17*) can respond up to 20,000 cycles per second.

Pneumatic thyratrons—essentially off-on power amplifiers—obey principles similar to those for electrical thyratrons, and will work as power switches or as power modulators. Switching is the simplest: control signal triggers thyratron, and full air pressure is applied to load.

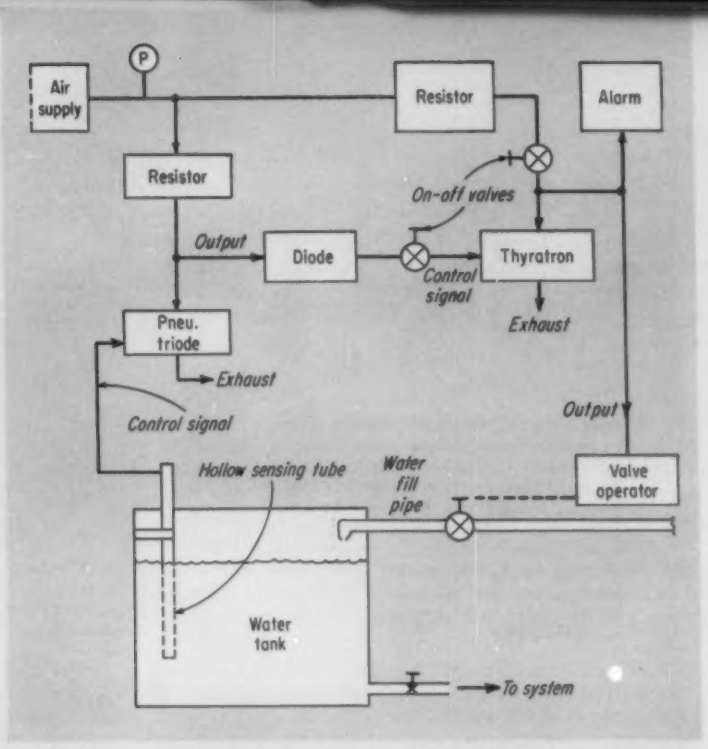
Power modulation with a thyratron (pneumatic or electric) requires carefully time-spaced control pulses so that the switched-on (transmitting) portion of each cycle yields the average power called for. The supply must be alternating (or pulsing), so that the thyratron will shut off at each half-cycle . . . otherwise it will not shut off at all, regardless of the value of the control signal. The supply frequency must be low (less than 1 cps for air) because it takes time for the thyratron to evacuate ("deionize"), once it is pressurized.

Pneumatic transformers (illustrated top of page) do

PNEUMATICS SIMULATES ELECTRONICS continued



SHORT-CIRCUIT and open-circuit analogy can be explained with these simple schematics. Pneumatic: if the stop valve is tightly closed, the circuit is blocked, analogous to an "open" electrical circuit. If the valve is opened, the circuit is "shorted" to atmosphere. Electrical: opening the switch opens the circuit, closing it closes the circuit (note that the terminology is opposite from that for the pneumatic circuit).



PNEUMATIC THYRATRON triode and resistors combine to give warning and open fill valve when water in tank drops to dangerous level. Air pressure in submerged hollow tube lowers slightly when water level drops, but pneumatic triode is sensitive enough to detect change, produce an output to trigger thyratron. Thyratron output sounds alarm, opens water valve to refill tank. Manual resetting of the system is necessary after a warning because thyratron will continue to conduct, keeping fill valve open. However, a second control circuit can be added to protect against overfilling.

not physically resemble electrical transformers because they are back-to-back bellows instead of coils. Yet the function is similar—to transform alternating-flow energy from one effective potential to another.

Combinations of resistors, triodes, capacitors, transformers and thyratrons can perform a wide variety of control functions. The water-level-control on this page is but one. Where higher pressure levels are needed, the amplifiers can be staged in series. A single amplifier can give 100:1 or even 500:1 pressure amplification. For higher power just increase size. Total pressure and power are limited only by the air supply available.

Another reason for combining elements is for "phase inversion." If a rising control signal normally causes a falling output, then two amplifiers in series will result in a rising output with a rising control signal. This is because output of each amplifier is 180 vector degrees out of phase with its input, totaling 360—which is equivalent to zero.

Stable operation of pneumatic circuits is a requirement, just as for electrical circuits. But for pneumatic circuits there are two basic ways to get a check: by building and testing the actual pneumatic circuit (or calculating it); and by building an electrical analog, taking advantage of well-documented electrical stability techniques.

Short circuits and open circuits (see schematic on this page) are a problem too. Even a leak—high-resistance, low-current partial short—can eventually drain (discharge) a capacitor or other energy-storage element.

For REPRINT of above article, just check P51 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Air for control has been the topic of these previous articles:

Pneumatic vs Electrical Control Elements, Apr 4 '60, p 52, introduces the concept of electrical-pneumatic analogies—gives simple examples of pneumatic devices that tend to obey electrical laws.

Valve with a Memory Handles Logic Circuits, May 26 '58, p 76, gives detailed descriptions of several types of "momentary" valves that can perform the digital function of MEMORY; included are sample circuits.

Design of Pneumatic Relay Circuits, Mid-Oct '56, p J-8, describes pneumatic circuits that can replace electrical for motor starting and other controls, and gives simple pneumatic equivalents for relays, pilot lights, fuses, switches and voltage-reducing transformers.

Moleculonics, Jan 18 '60, p 81, is a short abstract from the book **Moleculonics** (published by Modernair Corp), and shows typical pneumatic logic elements for the digital functions AND, OR, NOT and MEMORY.

Another analogous relationship is that between heat flow and electricity. Last week's issue had this article:

Heat-flow Analysis, May 2 '60, p 39, in which thermal problems are solved with electrical analogies.

The author thanks Dudley D. Nye, the engineer who first developed many of these electrical-pneumatic concepts, for his help.

VECTORS FIND STANDARD DEVIATION FASTER

Without a desk calculator, summing squares for this common statistical measure can be a long chore. Graphical method saves time, is as accurate as your plotting skill.

W HANKA
Military Aircraft Factory
Cordoba, Argentina

Data collected from reliability tests, quality control measurements and other engineering experiments are commonly distributed in a normal (or gaussian) pattern. The characteristic contour of this familiar bell-shaped curve is defined by its standard deviation: a peaked curve has a small standard deviation; a broad curve, a large deviation.

Though this is a recurring calculation in statistical work, it is not an easy one to make. If there are more than 10 or 15 readings, for example, subtracting the mean value, x', from each of the readings, x, and finding sum of squares can be tedious task. With a desk calculator the job is often simplified by rewriting the formula for standard deviation, σ, in one of the following forms:

$$\sigma = \sqrt{\frac{\Sigma(x - x')^2}{n}} = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n}} = \sqrt{\frac{\Sigma x^2 - x'\Sigma x}{n}}$$

where n is the number of readings. But if there isn't a desk calculator handy, you can plot the deviations graphically and, with a pair of dividers, arrive at a solution quickly and with nearly the same accuracy obtained by numerical methods.

In the graphic solution, two deviations are plotted at right angles and the sum found as if they were vectors. The Pythagorean relationship takes care of the sum of squares: the third side of the triangle, c, is the square root of the sum of squares of the other two, a and b.

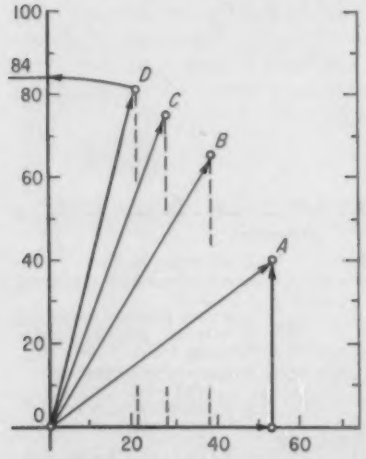
$$c = \sqrt{a^2 + b^2}$$

Thus, standard deviation for two deviations, $x_1 - x' = a$ and $x_2 - x' = b$, is

$$\sigma = \frac{c}{\sqrt{2}}$$

The method can be extended, of course, to any number of data points. The two examples shown below illustrate a shortcut plotting method in which both axes of the graph are calibrated to the same scale.

EXAMPLES



Problem: Find the standard deviation for a normal distribution of five points whose deviations from the mean value are 0.53, 0.40, 0.38, 0.28, 0.21.

Plot the first value, 53, on the horizontal axis and second value, 40, perpendicular to it to give point A and the vector sum OA. Then, instead of plotting the third value, 33, perpendicular to OA, plot it on the horizontal axis and with dividers, transfer OA perpendicular to the end of the vector to give point B. Continuing the process gives $OD = 0.84$ and standard deviation

$$\sigma = \frac{0.84}{\sqrt{5}} = 0.3763$$

When there are a large number of readings, but fewer different values, the recurring values can be handled as follows:

Find the production tolerances ($\pm 3\sigma$ limits) for a hole when measurements of 100 typical production units are (mean value, $x' = 1.6736$):

Dia of Hole, x	Frequency f	Deviation $(x-x')$	$(x-x')\sqrt{f}$
1.670	1	−0.0036	0.0036
1.671	3	−0.0026	0.0045
1.672	16	−0.0016	0.0064
1.673	23	−0.0006	0.0032
1.674	25	0.0004	0.0020
1.675	22	0.0014	0.0065
1.676	4	0.0024	0.0048
1.677	1	0.0034	0.0034

The $(x - x')\sqrt{f}$ values are added graphically as before to give a sum of 0.0128. Thus, standard deviation is

$$\sigma = \frac{0.0128}{\sqrt{100}} = 0.00128$$

and production tolerances are $T = \pm 3\sigma = \pm 0.00384$. A method for setting $\pm 3\sigma$ tolerances on mating parts was discussed in "A Faster Way to Set Statistical Tolerances," Mar 21 '60, p 55. ■

how to predict

WEAR LIFE of ROLLING SURFACES

No need to go back to comparable designs for a guide—use these equations to compute life expectancy of gears, cams, bearings, clutches and links

DONALD J MYATT
Associate Professor of Engineering
Antioch College, Yellow Springs, Ohio

When machine members having curved surfaces transmit loads from one member to another, an area of contact is developed, accompanied by compressive "contact" stresses. This condition is quite common—mating gear teeth, ball and roller bearings, cam and roller followers, roller chains and sprag-type clutches are typical of parts designed on the basis of contact-stress analysis.

To determine the maximum load that can be carried without undue wear, you usually refer to past performance records of similar designs. But there is a better way, based on a series of tests conducted by G. J. Talbourdet and W. C. Cram of United Shoe Machinery Corp. They determine load-stress K factors for various material and hardness combinations, and for various cycles of operation. With these values, the limitation on load capacity can be quickly determined for a desired wear-life expectancy.

To apply this concept in the design of components such as gears, cams and bearings, standard load or torque equations are revised here to incorporate the K factors.

THE *K* FACTORS

The formula relating contact stress to the load, material, and the geometry of cylinders in rolling contact parallel to their major axes was first given by Hertz:

$$s = 0.798\left[\frac{w\left(\frac{d_1 + d_2}{d_1 d_2}\right)}{\frac{1-\mu_1^2}{E_1} + \frac{1-\mu_2^2}{E_2}}\right]^{1/2}$$

Assuming that Poisson's ratio, $\mu = 0.3$ (a common assumption for metals), the above equation can be reduced to the form

$$w = \frac{K}{\left[\frac{1}{r_1} + \frac{1}{r_2}\right]} \qquad (1)$$

where

$$K = \frac{s^2}{0.35}\left(\frac{1}{E_1} + \frac{1}{E_2}\right)$$

and w is the load per inch of contact of the load-transmitting member.

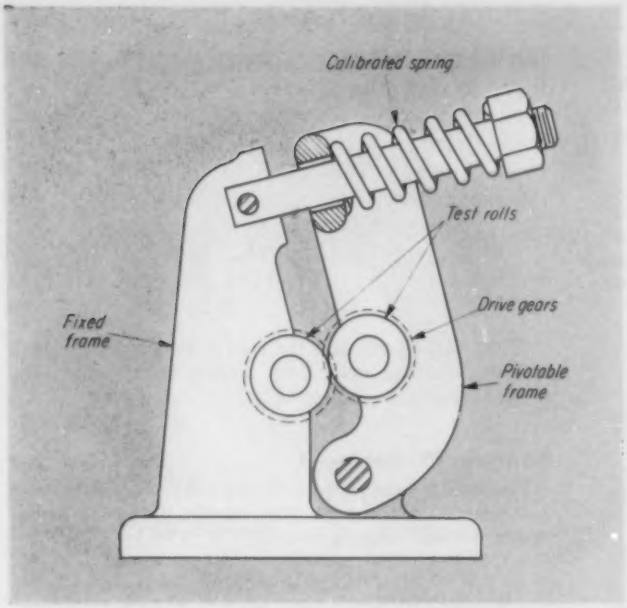
Quantity K is the load-stress factor for cylinders in contact. Values of K for various combinations of materials have been determined experimentally as a function of the number of stress cycles required to produce surface failure in the test specimens. Schematic of United Shoe's test machine, Fig 1, and its accompanying typical plot of test data obtained from 2.300-in.-dia gray cast iron rolls loaded in rolling contact are shown above. Results from tests on other materials tested in a similar manner are given in the K-factors table.

The test rolls are driven by gears in the test machine to give either a rolling action between test rolls (gear ratio is then 1 to 1) or a combined rolling and sliding action. Load is applied gradually by means of a calibrated spring until the desired load is fully exerted on the rolls. During tests, the rolls are amply lubricated with mineral oil—but lubrication and ambient conditions are easily varied to meet desired operating conditions. Tests are stopped when either roll begins to show appreciable wear. The number of revolutions or stress cycles is noted and factor K is calculated from Eq (1).

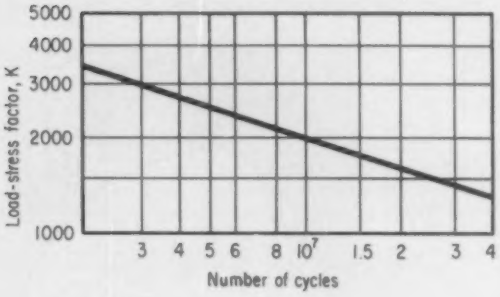
SYMBOLS

d = diameter of cylinder, roller or pitch circle of gear, in.
E = modulus of elasticity, psi
f = length of cylinder contact element or roller width, in.
F = load, lb
K = load-stress factor, psi
n = number of teeth, rollers or sprags in contact
r = radius of contact, in.
s = stress, psi
T = torque, in.-lb
w = load per inch of contact, lb/in.
α = cam pressure angle, deg
β = sprag gripping angle, deg
ϕ = gear-tooth pressure angle, deg
μ = Poisson's ratio
ρ = cam radius of contact, in.

(Subscripts 1 and 2 in equations pertain to mating members.)



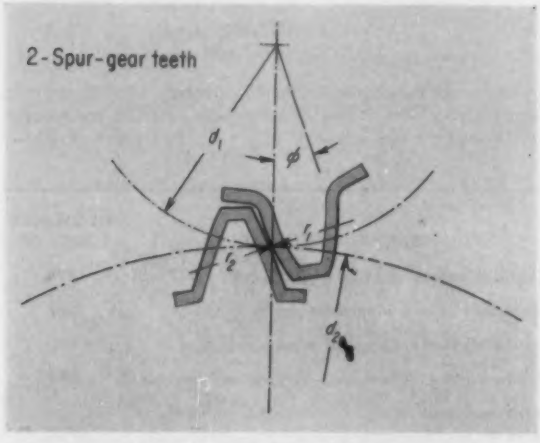
1—TESTING MACHINE, developed by United Shoe Machinery, determines K factors for cylinders in rolling or sliding contact. A typical K-N curve for gray cast iron rolls having a hardness 130 to 180 Brinell is also shown.



SPUR GEARS

Torsional loads based upon wear strength for involute spur gears made from various materials can be predicted by using Eq (1) and data from the K-factor table.

Values for r_1 and r_2 are equal to the radii of curvature of the gear teeth at the contact point, Fig 2.



Experience indicates tooth wear occurs most often in the vicinity of the pitch circle, and for contact at the pitch point:

$$r_1 = \tfrac{1}{2}[d_1 \sin \phi] \qquad r_2 = \tfrac{1}{2}[d_2 \sin \phi] \qquad (2)$$

where d_1 and d_2 are the pitch diameters of pinion and gear and ϕ is the gear-tooth pressure angle.

Torque on the pinion shaft corresponding to the load at failure predicted by Eq (1) is

$$T = \frac{f\, d_1 n K \cos \phi}{2\left[\frac{1}{r_1} + \frac{1}{r_2}\right]} \qquad (3)$$

Text continued on page 46

LOAD-STRESS K-FACTORS FOR VARIOUS MATERIALS

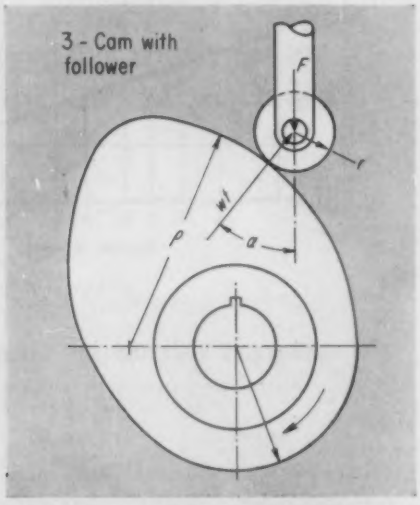
(Based on data presented by W. C. Cram at a University of Michigan symposium on surface damage)

ROLLER #1		ROLLER #2	K OF ROLLER #1 AT NUMBER OF CYCLES			
material	hardness	material	10^6	10^7	4×10^7	10^8
Gray cast iron	130–180 Bhn	Same as roller #1	4000	2000	1300	.....
GM Meehanite	190–240 Bhn		4000	2500	1950	.....
Nodular cast iron	207–241 Bhn		10,000	5600	....	3400
Gray cast iron	270–290 Bhn		7500	5300	4200	.....
Gray cast iron phosphate coated	140–160 Bhn	Carbon tool steel 60–62 Rc	2600	1400	1000	.....
	160–190 Bhn		3200	1900	1300	.....
	270–290 Bhn		5500	4000	3100	.....
SAE 1020 steel phosphate coated	130–150 Bhn		4500	2700	1700	.....
SAE 4150 steel chromium plated	270–300 Bhn		13,500	11,000	....	9000
SAE 6150 steel	270–300 Bhn		2600	1300	....	.....
SAE 1020 steel induction hardened	45–55 RC		21,000	14,500	....	10,000
SAE 1340 steel case hardened	50–58 RC		26,000	20,000	....	15,000
Phosphor bronze	67–77 Bhn		3600	1600	1000	.....
Yellow brass	Drawn		5600	3000	2000	.....
	Extruded		4500	2400	1700	.....
Zinc diecasting	.....		1100	500	320	.....
Laminated-graphitized phenolic	.....		1700	1300	1000	.....
Cast aluminum SAE 39	60–65 Bhn	Gray cast iron 340–360 Bhn	1200	500	300	.....

Eq (3) is applicable to the analysis of a pinion in mesh with an annular gear if the radius of curvature is treated as a positive number for the pinion with convex tooth profile, and as a negative number for the annular gear with concave tooth profile.

PLATE CAMS

As a plate rotates, Fig 3, the load between cam and roller follower varies; so does the radius of cam profile. For constant angular velocity of cam rotation, the



point of max contact stress between cam and follower may occur at: (1) max follower acceleration, (2) max pressure angle, (3) min radius of cam profile.

The force at the end of the follower stem corresponding to the load at failure predicted by Eq (1) and load-stress data from the K-factor table is:

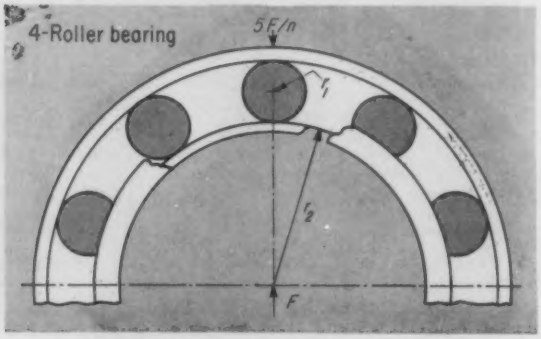
$$F = \frac{fK \cos \alpha}{\frac{1}{\rho} \quad \frac{1}{r}} \tag{4}$$

If a flat-faced follower is used instead of a roller follower, r goes to infinity in Eq (4) and the load becomes:

$$F = \rho f K \cos \alpha \tag{5}$$

ROLLER BEARINGS

Max contact stress inside a roller bearing occurs between the roller and the inner race, Fig. 4. The relation between the maximum-loaded roller in the bearing and an externally applied, radial load is given on page 54 of



Ball and Roller Bearing Engineering, by A. Palmgren (SKF Industries, Philadelphia, 1954):

$$w = \frac{5F}{nf} \tag{6}$$

Substituting this value into Eq (1) gives:

$$F = \frac{nfK}{5\left[\frac{1}{r_1} + \frac{1}{r_2}\right]} \tag{7}$$

This equation will give the max allowable bearing loads for roller bearings made from various materials, as illustrated by the following example:

Sample Problem—I

Determine the max allowable bearing load to avoid pronounced wear before 40 million stress cycles; calculate the load for various bearing materials. Bearing dimensions in inches are:

Outside dia = 4.3307
Bore = 2.3622
Width = 0.866
Inner-race radius, $r_2 = 1.439$
Roller dia = 0.468 (hence $r_2 = 0.234$)
Roller width, $f = 0.468$
Number of rollers, $n = 16$

Calculations:

For gray cast iron, from the K-factors table, $K = 1300$ at 4×10^7 cycles

From Eq 7:

$$F = \frac{(16)(0.468)(1{,}300)}{5(1/0.234 + 1/1.439)} = 391 \text{ lb}$$

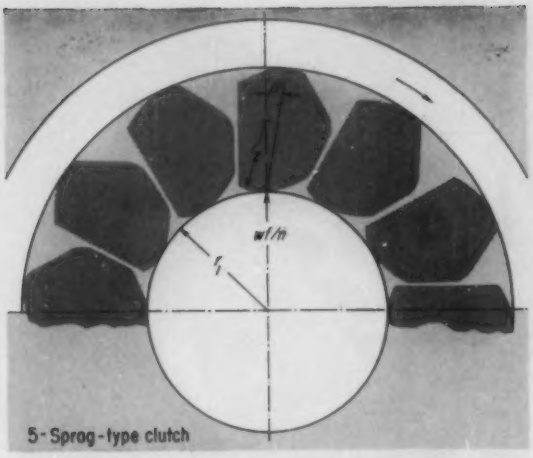
These calculations are repeated for the common material combinations listed in the K-factors table. Results are summarized below; the max allowable load varies by a factor of 10:

BEARING MATERIALS	ALLOWABLE LOAD, LB
Cast iron rollers, cast iron races	391
Meehanite rollers, Meehanite races	587
Hardened-steel rollers, cast iron races	300
Hardened-steel rollers, heat-treated cast iron races	933
Hardened-steel rollers, heat-treated medium-steel races	2700
Hardened-steel rollers, carburized low-carbon steel races	3912

SPRAG-TYPE OVERRUNNING CLUTCH

Torque is transmitted in a sprag clutch, Fig 5, by means of the wedging action of the sprags. Maximum contact stress occurs between the sprags and the inner race; torque capacity of the clutch can be derived from Eq (1) and the relationships of the various factors in Fig 5:

$$T = \frac{r_1 f n K \tan \beta}{\frac{1}{r_1} + \frac{1}{r_2}} \tag{8}$$



5- Sprag-type clutch

Sample Problem—II

Determine max allowable torque that can be transmitted by a sprag-type overrunning clutch made with hardened-steel sprags and case-hardened steel races. The clutch has the following dimensions in inches and must operate for 5 x 10^8 cycles:

Outer-race dia = 2.0592
Inner-race dia = 1.0580
Sprag radius, r_s = 0.282
Sprag length, t = 1.00
Number of sprags, n = 14
Gripping angle, β = 8°

Calculations:

$$r_i = 1.0580/2 = 0.529$$

K = 13,000 (From K-factors table)

From Eq 8:

$$T = \frac{(0.529)(1.00)(14)(13{,}000)(\tan 8°)}{(1/0.529 + 1/0.282)}$$

$$T = 2300 \text{ lb-in.}$$

Max compressive stress induced in the sprags and races is calculated from Eq (1):

$$s = 0.591\left[\frac{K}{1/E_1 + 1/E_2}\right]^{1/2}$$

$$s = 0.591\left[\frac{1300}{2/(3 \times 10^7)}\right]^{1/2} = 261{,}000 \text{ psi}$$

BEARING STRESS IN PINNED JOINTS

The bearing stress between a pin and a hole, Fig 6, is determined by dividing the load by the projected area of the pin:

$$s = F/fd \qquad (9)$$

A conservative design is obtained by using the allowable stress values for compressive loading, and by assuming that the pin joint is tight-fitting. However, the question comes up as to what is a tight-fitting joint.

By assuming that the pin and hole are members in contact, and by using $-r_s$ in place of $+r_s$ in Eq (1) (because of the concave surface of the hole), the following expression can be derived from Eq (1) and Fig 6.

6 - Pinned joint

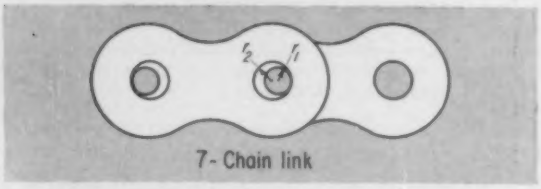
$$\frac{r_2 - r_1}{r_2} = \frac{r_1 fK}{F} \qquad (10)$$

If r_1 is known, a value for r_2 can be determined from the above equation. If this value is exceeded in the actual design, the contact stresses become critical and the joint should not be considered tight-fitting. In such a case, the limiting contact load on the joint may be determined as a function of the load-stress factor for the combination of materials used (from table), and from

$$F = \frac{fK}{\frac{1}{r_1} - \frac{1}{r_2}} \qquad (11)$$

Sample Problem—III

Determining the max hole dia for the link in Fig 7. The claim has medium-carbon steel pins, hardened-steel plates, and is loaded to 25% of its ultimate tensile strength. Select a proper clearance between hole and pin, and recommend the max allowable load. Dimensions are:



7- Chain link

Pitch = ¾ in.
Pin dia = 0.234 in. (r_1 = 0.117)
Plate thickness = 0.094 in.
Ultimate tensile strength = 8500 lb.

Calculations:

K = 9000 for 10^8 cycles (from K-factors table)
F = (0.25)(8500) = 2175 lb

From Eq (10):

$$\frac{r_2 - (0.117)}{r_2} = \frac{(0.117)(2)(0.094)(9000)}{2{,}125} = 0.093$$

$$r_2 = 0.129$$

Therefore, the hole dia, d_2, should not exceed 2(0.129) = 0.258 in. If a $\frac{31}{2}$ in. clearance is chosen, the hole dia will be:

d_2 = 0.234 + 0.031 = 0.265 in.
r_2 = 0.133

and from Eq (11):

$$F = \frac{2(0.094)(9000)}{\frac{1}{0.117} - \frac{1}{0.133}}$$

$$F = 1{,}650 \text{ lb}$$

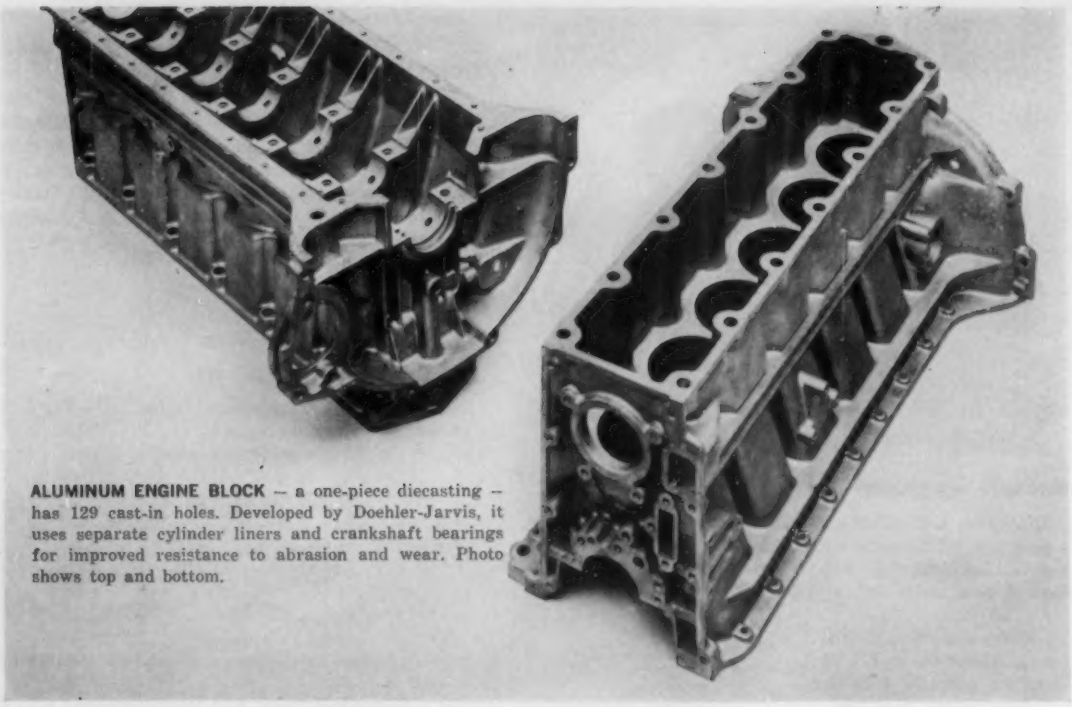
This is the maximum load that can be carried without failure from contact stresses.

For REPRINT of above article, just check P50 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE—For more information on wear of sliding parts see:

Wear of Lubricated Surfaces, Apr 13 '59, p 74. An on-the-spot report of ASME's lubrication symposium at Franklin Institute, Philadelphia. Includes latest findings on spur-gear wear, engine wear and the use of four-ball testing method.

ASLE's Gear Symposium—Emphasis Is on Experimental Methods, Feb 16 '59, p 64. Highlights include comparison of various gear -testing rigs, and new formula for wear of oscillating parts.



ALUMINUM ENGINE BLOCK — a one-piece diecasting — has 129 cast-in holes. Developed by Doehler-Jarvis, it uses separate cylinder liners and crankshaft bearings for improved resistance to abrasion and wear. Photo shows top and bottom.

ALUMINUM DIECASTINGS— the field widens

A new alloy and an improved process promise more applications for them. Here are the details, together with a rundown of design tips for die-casting this light metal.

HERBERT L KEE, *assistant editor*

Although they cannot compete with zinc for purely decorative forms, aluminum diecastings fulfill many mechanical requirements for structural components. And two new developments—a new alloy and a refinement of the vacuum die-casting process—promise to give them even broader applications.

Besides generally being the cheapest die-cast metal per volume cast, aluminum offers these advantages over zinc:

- High yield strength without room-temperature creep.
- Retention of strength at low temperatures as well as at moderately elevated temperatures.
- Dimensional stability.
- Resistance to atmospheric corrosion without further finishing.

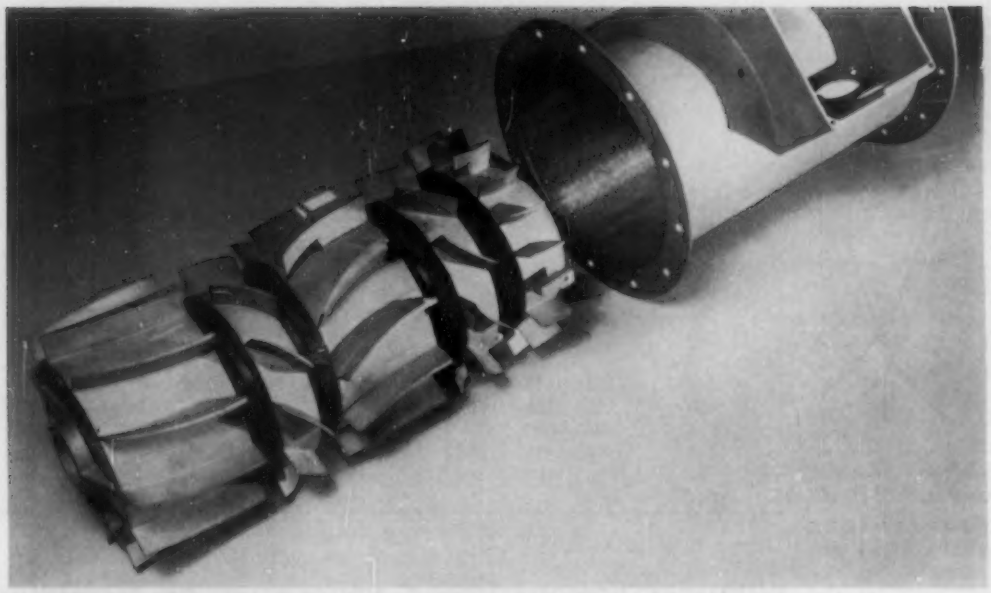
Ability of aluminum die-casting to produce finished shapes gives further savings where machining, assembly or surface finishing account for an appreciable portion of final costs. Also, indirect savings result from light weight, which reduces static and dynamic loads and gives uniform part-to-part dimensions necessary for better fit and easier assembly.

Disadvantages of the method include:

- High initial tool cost.
- Greater die wear.
- Shape limitations—only simple cored passages are practical; there should be no radical changes in section thickness.

NEW VACUUM PROCESS

The latest development in the field is a vacuum die-casting process recently announced by the Die Casting Research Foundation. This refinement of existing vacuum processes draws a vacuum on the cavity only when the metal is injected into the die. The part-time suction



LOWER ROTATIONAL STRESSES and bearing loads result from designing high-speed blower from six diecastings. Aluminum cuts mass of rotor, which runs at 9600 rpm. At these speeds, rotor becomes a gyroscope, resisting angular acceleration. Higher mass with heavier materials increases recessional forces on the bearings.

◀ **MINIMUM WARPAGE** and low die cost call for ejection from one side of the die. Cast detail—bosses on hand-mixer base (bottom) and vanes on centrifugal blower (top)—give consistent ejection.

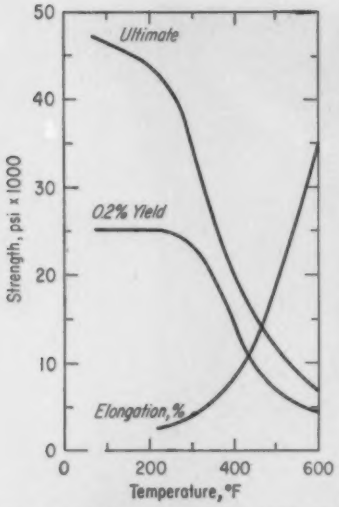
reduces the vacuum capacity needed, and keeps the equipment costs to a minimum. This vacuum process is available to Die Casting Institute members but not to the general industry. However, the other vacuum processes are being offered by manufacturers of die-casting equipment, so use of vacuum is becoming more widespread. In some versions, the vacuum draws the molten metal from the furnace into the cold chamber. Vacuum, an assist to die venting, gives smoother surface finish, permits thinner walls, and produces less porosity than conventional die-casting methods.

NEW ALLOY DEVELOPED

A new material, designated 364, has been added to the growing family of special aluminum die-casting alloys. Containing silicon, magnesium, chromium and beryllium, it has castability equivalent to the best die-casting aluminum and ultimate and yield strengths of 41,000 psi, 22,000 psi and elongation of 7.5%. Its annealed ductility is sufficient to permit 180° bends about 1½ times the diameter. Higher cost is its main drawback—price of the material is about 10% higher than for other aluminum die-cast alloys.

The new alloy combines high strength formerly found only in 218 (which can be cast only in simple shapes) and the excellent casting properties of the 13 alloy. The 364, like all commercial die-casting alloys, has alloying elements to improve mechanical properties and to increase castability by shortening the solidification range, increasing fluidity while molten, and reducing shrinkage upon solidification. Alloying also contributes indirectly to castability by: lowering the thermal coefficient of expansion of the solid metal, decreasing die-soldering tendency and increasing resistance to hot tearing or cracking. The alloying constituents for the 364 alloy are:

Silicon—primary alloying element in 364—lowers melting temperature and increases fluidity of the molten metal. This makes silicon-aluminum alloys useful for large castings and parts with intricate shapes. While the tensile strengths of straight silicon alloys are relatively low, they



ELEVATED-TEMPERATURE PROPERTIES of 364 alloy are similar to those for alloy 360.

SELECTION GUIDE TO ALUMINUM DIE-CASTING ALLOYS

(figures indicate relative desirability)

Alloy	Melting Range, °F	Castability	Resistance to hot cracking	Pressure tightness	Strength at elevated temp	Resistance to corrosion	Machinability	Ease of polishing	Adherence of electroplate	Anodized appearance
Standard Alloys										
13	1065–1080	1	1	1	3	3	4	5	3	5
380	1000–1100	2	2	2	2	4	3	3	1	3
Special Alloys										
364	1035–1115	1	1	1	1	2	3	3	1	3
360	1035–1105	1	1	1	1	2	3	3	1	3
39–11	960–1080	1	2	2	2	4	3	3	2	4
218	995–1150	4	5	5	4	1	1	1	5	1
43	1065–1170	3	2	3	5	3	5	4	2	2

CHEMICAL COMPOSITION & PROPERTIES OF ALUMINUM DIE-CASTING ALLOYS

	Standard Alloys		Special Alloys					
Commercial Designation	13	380	364 (as cast)	364 (aged)	360	39–11	218	43
Alloying Agent, %								
Copper	0.6	3.5	.....	.....	0.6	3.5	0.25	0.6
Silicon	12.0	8.5	8.5		9.5	11.3	0.35	5.2
Magnesium	0.10	0.10	0.30		0.50	0.10	8.5	0.1
Other	.....	.....	0.3 Cr, 0.03 Be		.....	.....	.....	.....
Properties								
Ultimate Strength, psi	43,000	48,000	41,000	46,000	47,000	43,000	45,000	33,000
Yield Strength, psi	21,000	24,000	22,000	33,000	25,000	27,000	27,000	16,000
Elongation, %	2.0	3.0	7.5	4.0	3.0	2.0	7.5	5.0
Shear Strength, psi	28,000	31,000	26,000	——	27,000	28,000	29,000	21,000
Fatigue Strength, psi	19,000	21,000	18,000	——	19,000	19,000	20,000	17,000

give sound sections so that actual strength of the part may be higher than for parts made from alloys with higher nominal strength, but poorer castability. The silicon alloys have good resistance to corrosion (though poorer than pure aluminum) but are difficult to machine. Silicon 364 and 13 alloys give a poor appearance to anodized coatings, which turn gray or brown.

Other alloying elements act in conjunction with the silicon. This alloy system for 364 is unique because the benefits it derives from the various alloying elements are interdependent—that is, none of the elements alone would give the desired combination of mechanical properties and castability.

Because another objective was to attain an alloy that could tolerate the usual amount of iron impurity, development of the system started with an aluminum-silicon alloy with about 1% iron. The iron increases ultimate strength but gives low yield strength and poor ductility. Chromium and beryllium additions increase both ultimate and yield strengths and improve ductility and high-temperature strength also. (Chromium by itself will raise yield strength, but lower ultimate strength and elongation. Beryllium alone will increase elongation, but lower tensile properties.) Addition of about 0.3% magnesium increases ductility further and promotes strengthening by age hardening.

Impurities have as little effect on the properties of 364 as on other aluminum die-casting alloys. This contrasts with zinc die-casting where small amounts of impurities drastically change properties and casting characteristics. Iron should be below 2%. Although it increases strength and lessens tendency to solder (a major factor in die wear), high iron content makes the material brittle and hot-short. Copper can be tolerated in quantities up to 0.2% and manganese, zinc and nickel up to 0.1%. Tin and lead residual impurities in secondary aluminum are not harmful.

GROUND RULES FOR DESIGN

Good castability of 364 allows design to deviate more from the ideal die-cast shapes. In general, rules for good casting design also apply to die-casting. In addition, there are special rules specifically for die-casting, because the process injects metal under pressure, and the metal dies rapidly chill the molten metal. Here, solidification takes place in a relatively short time and progressive solidification is not as pronounced as in sand or permanent-mold castings.

Wall thicknesses should be uniform as possible, with thick-to-thin sections tapered gradually. Heavy walls should be accessible from the outside of the casting, so that metal can be injected directly without forcing the metal to flow first through thin sections. Although there is no limitation on the maximum thickness (cast sections up to several inches thick are possible), walls should be kept thin to maintain high production and achieve the high strengths from the chilled metal. Practical minimum for walls varies with the size and complexity of the casting and castability of the alloy. For difficult casting conditions a good minimum is $\frac{1}{16}$ in., to insure proper flow of metal in the die. Where the casting is small, its shape is simple and the metal is fluid, walls may be as thin as 0.050 in. Walls should be heavier (about 0.125 in.) if subsequently polished surfaces are to be free from small casting imperfections.

Ribs add strength and rigidity to thin sections. They also make a part easier to cast by providing channels for metal flow. Usually rib thickness is about 0.7 to 1.0 times the adjoining plate thickness. Depth of ribs is not fixed, but deeper ribs are usually possible with more castable alloys. Deep ribs also require more draft.

Fillets for maximum strength should equal adjoining wall thickness. Although castable alloys can fill sharp corners, easy casting here is secondary to mechanical strength of the part. When not required for strength, fillets should be at least $\frac{1}{32}$ in. If external corners are given a slight radius, die costs are reduced.

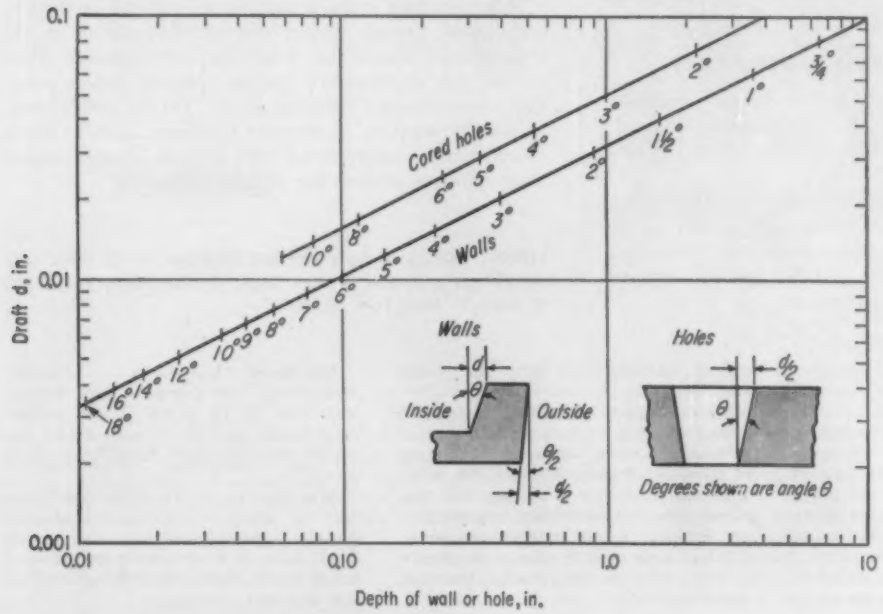
Undercuts should be avoided; there are many ways to get around them. Here the diecasting producer can give valuable advice by estimating the costs of various designs or by suggesting cheaper alternatives without undercuts. Typical ways of avoiding undercuts in castings are: extending projections to the parting line, altering shape of cored holes, shifting holes or walls of the parts to permit an irregular parting line and use of inserts.

Ejecting-pin placement is fixed from shape of the part. Although these ejection forces should be minimized for easy ejection from the die, they should not be entirely eliminated. Instead, the design should intentionally make parts bind slightly on one side. This prevents the warping and twisting that would result if one part of the casting sticks to one die half and the other part to the other die half. Also die costs are lowered if ejection pins are built only into one die half. To make the casting stick slightly, but consistently, to the ejection side of the die, keep most of the bosses and cores on the ejection side, or increase the draft on the side opposite.

Other design criteria such as dimensional tolerances, (given in the table on next page), and draft, (charted on this page), apply to all aluminum diecastings. They are from the engineering standards published by the American Die Casting Institute, and were determined by representative members of the die-casting industry. In specific cases, better tolerances than those specified can be attained—sometimes without any additional cost. However, unless a producer is consulted, it is best to assume that the figures shown will give the most economical parts.

MACHINING THE DIES

Advance methods of machining have freed diecasting shapes from many former limitations. The electro-



RECOMMENDED DRAFT for aluminum diecastings applies generally for all alloys. Draft for cored holes is total draft for both sides; draft on outside walls is ½ that for inside walls.

Tolerances for Aluminum Diecastings

Linear tolerance for critical dimensions:

±0.004 in. for dimensions up to 1 in.
add ±0.0015 in. for each additional inch up to 12 in.
add ±0.001 in. for each additional inch over 12 in.

Linear tolerance for noncritical dimensions:

±0.010 in. for dimensions up to 1 in.
add ±0.002 in. for each additional inch up to 12 in.
add ±0.001 in. for each additional inch over 12 in.

Flatness tolerance: 0.008 in. for surfaces up to 3 in. length
add 0.003 in for each additional in. length

Other tolerances (add to linear tolerance)

Parting line	Area of Casting, sq in.	tolerance, in.
	up to 50	±0.005
	50 to 100	±0.008
	100 to 200	±0.012
	200 to 300	±0.015
Moving die	**Area of Casting, sq in.**	**tolerance, in.**
	up to 10	±0.005
	10 to 20	±0.008
	20 to 50	±0.012
	50 to 100	±0.015

machining processes (*PE–Mar 2 '59, p 59*), now faster in cutting rate, can compete with more conventional die-machining practices. With electromachining, any shape is practical if it can be made in brass as a male master to erode the female impression. Up to now, rules for die-cast shapes have been governed by the practical limits of profile milling with tapered round-nose cutters. For example, with new techniques uniform radii are not necessary. Still, parts that conform to the older, conservative designs may result in a more competitive price bidding because not all shops are equipped with these advanced tools.

FINISHES FOR CORROSION RESISTANCE

Alloys 364 and 360 have slightly less corrosion resistance than 218, and excellent casting characteristics. Alloys 13 and 43 have only fair corrosion resistance, but are satisfactory for most indoor applications.

Aluminum alloys resist corrosion because of a layer of adherent oxide that forms at the surface, so they usually can be used with little or no added protection. Aluminum is not resistant to strong alkalis and also must be insulated from electrolytic action with copper.

When the natural aluminum oxide is insufficient, an anodize treatment gives added protection. Here, suitability of a material might well be judged from the appearance of the anodized coating. Although the coatings are protective, the silicon alloys have a poor anodized appearance. Alloy 364 turns gray and the 13 alloy turns a dirty brown. For decorative purposes, 364 is rated high in adherence of electroplated coatings. Aluminum alloys do not need special treatments to promote adherence of organic paint films. Chemical cleaning or conversion coatings are usually sufficient.

PRESSURE TIGHTNESS IN DIECASTINGS

Diecastings tend to leak when they contain fluid under high pressures. If leakage cannot be tolerated, diecastings cannot be used. The leakage characteristic is inherent in the process and due to oxide films formed by flow of the plastic metal. Although these films are structurally sound, leakage will follow these planes, so impregnation should always be specified for pressure castings. In general, more castable material and thinner walls are not so apt to leak. Machined castings almost always leak. Some simple castings, which can be well gated and vented, have been satisfactory up to 1000 psi but these castings were not machined.

Impregnation is economical when pressure tightness must be ensured. Sodium silicate is the most common impregnant but the organic sealants such as tung oil, linseed oil and synthetic resins are becoming more common.

Techniques for impregnation differ. Some use pressure alone to force the sealant into pores; others pull a vacuum to open the pores, then inject sealant by a pressure cycle. The sealant is then baked to dry or cure it. Generally, baking temperatures should be kept under 350 F to avoid over-aging the aluminum, and changing its mechanical properties. Afterward, castings are thoroughly cleaned, because films of impregnant prevent formation of the natural oxide coating on aluminum.

When casting requires additional surface protection, the coating process decides whether the coating or the impregnation should be done first. Acid-anodize treatments, such as Alumilite, tend to open up surface pores, and so may require reimpregnation. On the other hand, an alkaline-anodize, dichromate treatment such as Alrok should not be impregnated with sodium silicate because these solutions destroy the protective film.

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EDITOR'S NOTE: Other mass-production processes for turning out complex parts have been described in:

For Small Parts . . . Zinc Die-casting Cuts Costs, Apr 18' 60, p 65. Inexpensive, single-cavity method with built-in finishing tools gives up to 300 parts per minute and tolerances as close as ±0.0005 in. It's best suited for minimum runs of 100,000 pieces.

For Tiny Parts—Minicast Does It Cheaper, Feb 1 '60, p 44. Process using plastic patterns is suited to 1-in. dimension parts in quantities over 25,000; allows design to specify high-strength alloys and close tolerances.

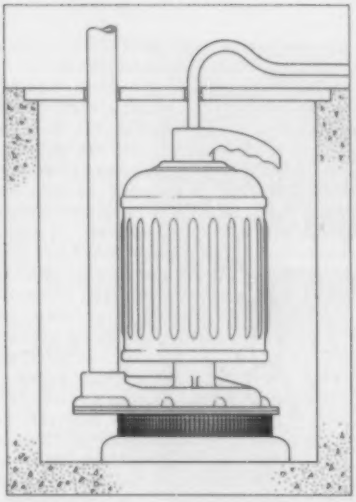
How to Choose—Investment Casting or Sintered Powder, June 8 '59, p 86. Although investment casting and sintered metal powder seem competitive for making small mechanical parts, a closer look usually shows the choice is easy, once you know what the part must do.

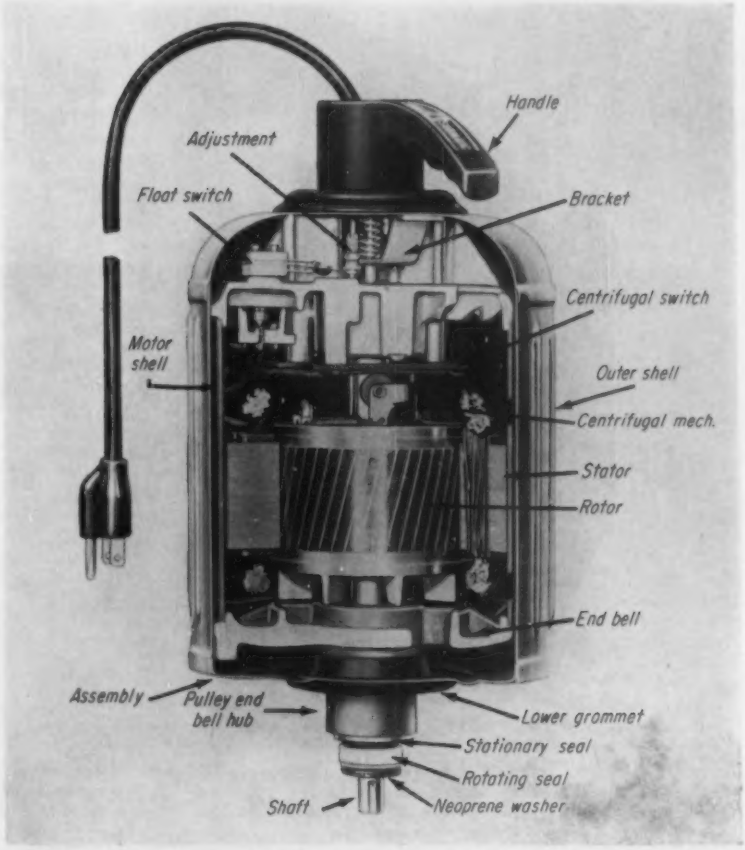
For Many Thin Parts . . . Powder Metallurgy Can Compete with Stamping, May 11 '59, p 82. When powder metallurgy should be considered for many parts normally made from sheet metal.

Slip Casting . . . Its Field Broadens, Oct 13 '58, p 84. Describes slurrgy method now moving into the metals field, tells how it stacks up against other metal-powder processes such as hot and cold pressing.

Float Houses Pump Motor

An outer shell serves as actuating float for this sump pump motor; the same bronze can keeps water from the motor.

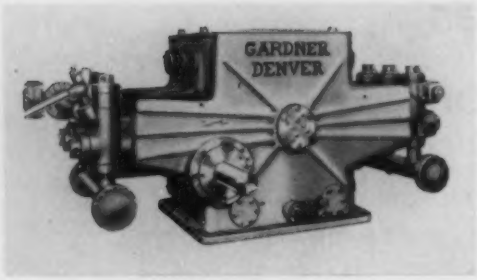




PUMP MOTOR starts when the water rises to preset level in the pit in which unit is installed. The outer shell rises to actuate the sealed switch, and the pump operates in or under water until the water level lowers. As this level goes down, the floating shell drops too. At cutout level, it switches the motor off.

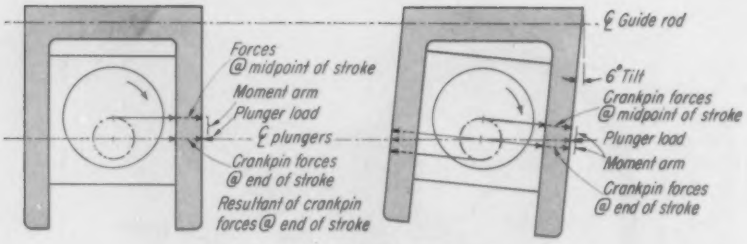
The surrounding shell is attached to the motor end bells by means of rubber grommets, which permit vertical movement of the case while the motor is rigidly fastened to the pump. A bracket attached to the shell actuates the internal control switch. An externally rotated screw permits adjustment of the point of switch operation of the shell.

PS . . . The motor is inside the corrosion-resistant, hermetically sealed shell. Position setting of this float-case can be adjusted without removing cover or other parts. Available in ⅓ to 1 hp in fractional increments. Submatic sump pump motor is produced by Franklin Electric Co Inc, Bluffton, Ind.

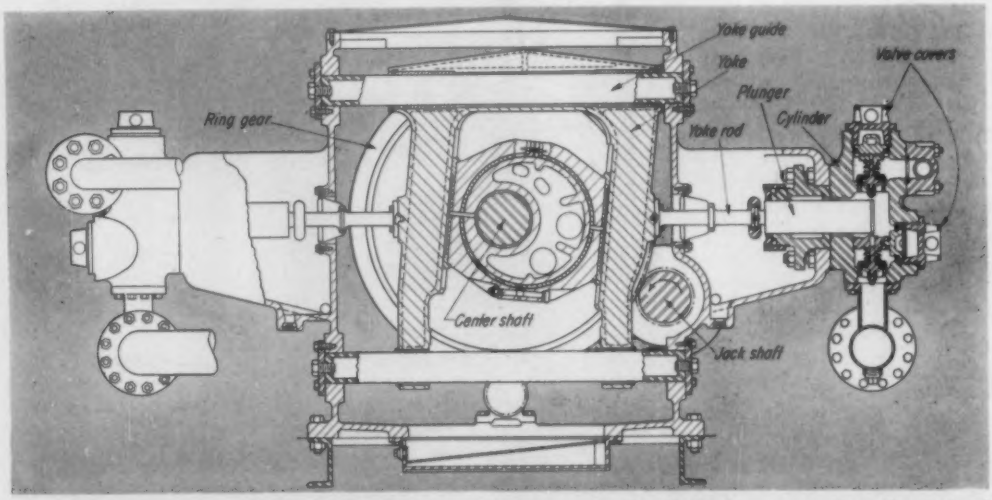


New Angle Reduces Strain on Pump

Inclining the scotch yoke of this mud pump just 6° from normal cuts bending moments in half. Interchangeable plungers and cylinders permit field overhaul with minimum downtime.



TILTING YOKE 6° from normal reduces the bending moments that occur when eccentric cam reaches maximum offset in relation to the plunger axis. Comparative force diagrams, plotted for the yoke positioned vertically, and tilted 6° in the direction of rotation, show a reduction in moment arm of approximately 50% for the tilted position.



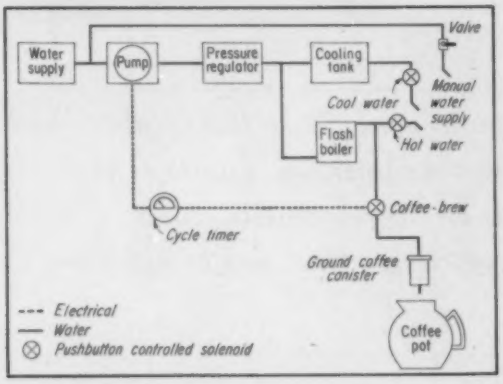
ASSEMBLIES OF CYLINDER BANKS are externally mounted and include suction and discharge valves. Threaded valve covers permit rapid access to valve retainers and valves. Quick-disconnect fitting between plunger and yoke rod speeds removal of a cylinder bank for repair or replacement. Downtime to connect or disconnect plungers is matter of minutes. One side of pump—three cylinders—can continue operating while repairs are made on opposite side.

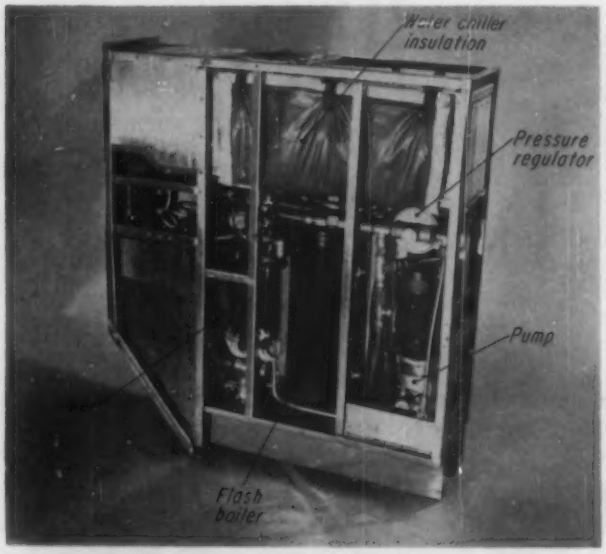
Two helical gears, cut on the motor-driven jack shaft, are meshed with helical ring gears bolted to the eccentrics. By opposing the helix direction of the jack-shaft spur, internal thrust is balanced out. The eccentrics rotate on, and are supported by, the center shaft—which passes through the pump housing. Upper and lower guide rods restrain the yoke in which the eccentric follower slides. Sheet steel cover provides access to all moving parts.

PS . . . Three-phase action of the 6-cylinder pump produces near-linear pressure curve. This eliminates need for dampers or surge chambers in delivery line. Pump is driven by a 650-hp motor at 130 rpm, gives 465 gpm at 2040 psi with a 5-in. bore, 7-in. stroke. Developed for oil-well drilling, Model PO-7 pump is produced by Gardner Denver Co, Quincy, Ill.

Plastic Cartridge Brews Faster Coffee

With these quick-change containers, airborne coffee brewer provides eight cups in three minutes. Flash boiler readies water for another cycle in 40 seconds. Unit operates successfully up to 20,000 ft.





FOR FRESH COFFEE, pot is inserted in spring retaining-clip under cartridge. When stewardess presses "Coffee-Brew" button, water at 190 F is forced at 15-20 psi through the ground coffee and into the pot. A timer limits flow to 8 cups (55 oz) and shuts off the water. To prepare for next batch of coffee, stewardess inserts a fresh cartridge in canister. Meanwhile, flash boiler refills and heats water to proper temperature in 40 seconds. "Brew" sign lights up when water is ready. If coffee pot is not positioned properly in spring retainer, an interlock switch prevents operation.

Track mounts and quick-disconnect fittings link coffeemaker to the plane's water and electrical system. This simplified installation and removal is required because cleaning and servicing is handled by food-service personnel.

PS . . . Needing less than 2 cu ft of space and weighing 54 lb, multipurpose unit also dispenses hot water for tea, bouillon or hot chocolate, and chills drinking water as well. Flash boiler holds 110 oz; draws 2500 w at 200 v (ac) to maintain water at 190 F—the boiling point at 10,000-ft altitude. (Cabin pressure is usually kept below this level.) Water chiller holds 45 oz, is cooled by a tray of dry ice above it. Liquispenser is produced and installed in REF Skygalleys by REF Manufacturing Corp, Mineola, NY.

REUSEABLE CARTRIDGE holds 3.2 oz of ground coffee, is made of polypropylene because this plastic does not absorb flavor or color, does not impart a foreign taste, and has high rigidity with little shrinkage in molding. Stainless steel mesh, molded into cartridge bottom and cover, prevents escape of coarse solids into the brew.

Two-piece stainless steel canister, which holds the coffee cartridge, has outlet at bottom and inlet tube in the cover. Positive sealing is provided by three pins in the cover. They engage bayonet-type cams on upper lip of the canister body. Plastic handle is held to the body by brazed studs.

DOES YOUR NEW-PRODUCT IDEA MEASURE UP?

Among all the candidates, how do you choose the "right" one? This technique cuts guesswork—analyzes a number of promising ideas throughout their development, then methodically eliminates the weaklings that can't meet predetermined standards.

CLARENCE HUETTEN, *director, Electrophysical Laboratories, and*
LOUIS SWEANY, *senior engineer*
PR Mallory & Co Inc

Choosing a new product for development is an important decision. But too often it's an all-or-nothing gamble. You're forced to decide on the basis of guess and hope, and then carry on—no matter how bad the guess was, or how the engineering or market situation changes.

There is a more realistic approach. It recognizes that many starting ideas will never get to production—perhaps 99 out of 100 will drop along the wayside. And it helps you spot the nonprofitable candidates early in the elimination contest—less time and money wasted on ideas that won't pan out.

This method starts all ideas through the development mill on an equal basis. But at seven distinct stages you force a formal reevaluation of the idea in terms of the company's criteria of acceptability. If it passes, fine. Send it on to the next stage. If it doesn't, file the idea for future reference—times change and the candidate might look altogether different in five or ten years.

Note that this system adds hours and dollars to product-development budgets, but it reduces risks—so much so that successful products pay for all their own development, and for all the drop-outs as well.

DECISION CRITERIA

At each stage the basic question asked of a new product is: "Will it make money?" Various tests can be applied—the significance of each depends on the type of company and its policies. Three factors that always interest prospective investors are:

Ratio of gain to risk. Will profit exceed expense by enough to make the risk worthwhile? The company must set a minimum ratio (generally about 2.5:1) for proposed new products. This ratio then becomes one of the criteria applied at each step.

Estimated annual dollar volume. Will over-all volume be a satisfactory proportion of the company's annual business? Again the company must set a minimum limit. The new product may be acceptable by other criteria, yet represent too small a percentage of the over-all goals set by the company.

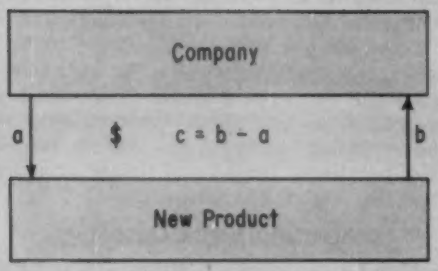
Break-even time. How long will money be tied up before a return can be expected? The company must set a limit on how much time its money can be unavailable for other use.

These are not the only criteria that can or should be used as a measure of acceptability of a new product. Other decision factors generally considered during the idea-screening process should be applied at each of the seven distinct stages of reevaluation (see "Seven Steps of Analysis," at right).

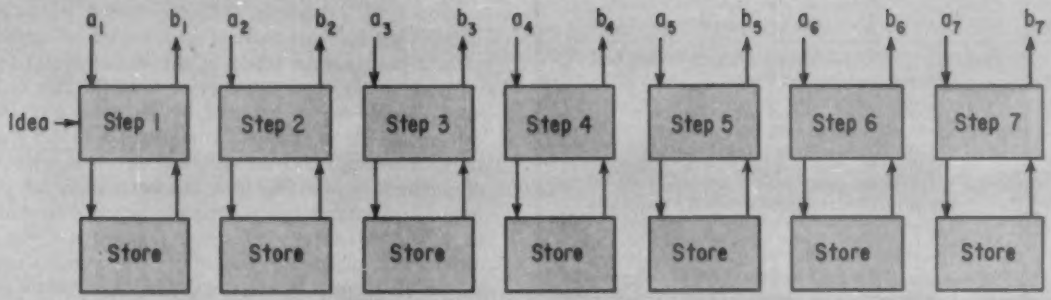
At the end of each stage the criteria are applied in the light of the new information made available, and a decision is reached—does the product justify further development? Note that the gain-to-risk ratio for each individual product does not include expenses incurred by all other products under evaluation. This ratio must be adjusted

text continued on page 58

SEVEN STEPS OF ANALYSIS



BASIC BUSINESS CONCEPT (left): company spends a dollars on new product, expecting return of b dollars for a gain of c dollars over life of product ($c=b-a$). Basic concept is broken down below into 7 steps.



1. Is an idea worth considering at all? Past experience, a brief literature search, and an informal market analysis will tell you. Select a descriptive name and define the scope of the idea. Write general requirements, which should be rather brief and not too restrictive for later method or approach. Estimate and calculate a's and b's. On this basis the idea is either accepted, or rejected and stored for future review. Recording the information and making the calculations necessary to complete the analysis should take less than half an hour and give the answer —is it still a good idea?

2. Next, make a detailed study of technical requirements. Is the idea feasible? Obtain opinion from experts in marketing, production, and engineering; and make a literature search. Now you can make a basic proposal. Each idea analyzed here may cost several times that of a Step 1 analysis. Should you go on?

3. Now test basic technical features and make a formal, but brief, market analysis. This is the critical step in the technical life of the new idea—which idea has come this far on the strength of a number of "ifs", both in technical features and market aspects. Conduct sufficient laboratory exploratory work to assure feasibility of the approach. If possible, make a demonstration model. What will it cost to make? How much can it be sold for? At that price, what market can be expected? Have a preliminary patent search made. Are there any infringements? With all this information reestimate the a's and b's and the acceptance criteria. Are you ready to proceed with a formal proposal to management for a full-scale R & D program?

4. Set up a comprehensive technical development program and make a thorough market analysis. Review technical requirements to make sure nothing has been omitted and that they are in keeping with the expected performance of the product. At the end of this stage recalculate a's and b's. Is the product worth further effort?

5. Here you design and tool up for production, purchase material for initial production, and train production personnel. The sum of all costs up to and including this step determines maximum financial risk in the product. Acceptance criteria should be periodically reviewed during this phase, using the latest information available from the manufacturing unit, market research, and other sources.

6. Analysis here determines the breakeven point in the financial history of the new product. The breakeven point reflects all costs to date. During this phase, costs and income should be periodically reviewed. The acceptance criteria are then applied to the latest analysis. Significant changes may indicate advisable corrective measures.

7. Adjust production levels to suit the market. Continue until profits decline.

Subject: PRODUCT X		No. / Date:
	ESTIMATE	REMARKS
p	$1.50	Selling price
V_m	1,300,000	Unit volume per year (max)
f_m	1,950,000	Dollar volume per year (max)
t_a	2	Acceleration time, years
a_1	COSTS 50	Preliminary analysis
a_2	250	Analysis and paper approach
a_3	2,500	Analysis and exploratory
a_4	35,000	Research and development
a_5	108,916	Tooling, pre-production, interest, etc.
a_6	1,891,169	Expenses during breakeven period
a_7	9,963,429	Expenses during remaining production time
a	12,001,314	Total Expenses (sum of a_1 thru a_7)
b_1	INCOME 0	None expected
b_2	0	None expected
b_3	0	None expected
b_4	0	None expected
b_5	0	None expected
b_6	2,037,885	To break even
b_7	10,736,454	During remaining production time
b	12,774,339	Total Income (sum of b_1 thru b_7)
t_1	TIME	Analysis
t_2	0.2	Analysis and paper-approach
t_3		Analysis and exploratory
t_4	1.0	Research and development
t_5	0.5	Tooling and product engineering
t_6	1.9	To break even
t_7	6.4	Remaining production time
t	10.0	Total Time (sum of t_1 thru t_7)
c = 773,025 (net gain)	d = 146,716 (risk)	c/d = 5:1 (gain/risk)

SAMPLE SUMMARY SHEET, containing all information necessary for making decisions. Data shown is for typical product X at stage. 1. Here, the *a*'s, *b*'s, *c* and *d* are in $; *t*'s are in years. Similar sheet is used for each stage, providing complete history of product.

upward so that when expenses of all drop-outs are added, the ratio will still be within company requirements.

SUMMARY SHEETS

The system is simple to use when the analysis is summarized for permanent record. The single summary sheet shown above collects the many lists of information necessary and organizes them so that acceptance criteria can be applied at a glance. It contains estimated selling price; annual unit and dollar volumes; acceleration time; *a*, *b*, and *t* factors; gain, risk, and gain-to-risk ratio. It should also include any other factors you require as acceptance criteria. This sample sheet includes data for a mythical product X, which will be described later. For now, let's consider the form itself.

The *a*'s represent expenses at each step; *b*'s represent expected income at each step; and *t*'s are the time the product spends in each phase. The sum of a_1 through a_6 is the maximum risk, called *d*. Net gain, *c*, is calculated by subtracting the sum of a_1 through a_7 from the total of all *b*'s. Gain-to-risk ratio, c/d, is gain divided by risk.

Selling price must be estimated directly or developed through costing and profit calculations. Assuming something is known about the potential market for the product from published market figures, an estimate can be made as to what portion of this market your company might expect to capture at the estimated selling price. Because most products have a growth period, a relatively stable period of production, and then a period of decline, an estimate can be made of maximum expected yearly volume, V_m. Selling price times maximum unit volume gives maximum dollar volume.

Because of the number of assumptions necessary for calculation of acceleration time, t_a, the explanation is incorporated in the typical product analysis described below.

Behind each summary sheet lies a lot of detailed information which should be available for examination if questions arise as to how certain estimates were made, etc. The supporting sheets should contain raw data, methods of calculating, and a log of thoughts concerning the product and market information.

COLLECTING INFORMATION

Information for the analysis is mainly dependent upon estimates guided by factual information that can be had economically. Obviously, full-scale market researches and detailed product-cost analyses on hundreds of new-product ideas should not be made in the earlier steps. You can estimate product-cost information from the cost of known items already being produced by the company. In time, a reference file of material, labor, and overhead costs can be accumulated. Market information on a wide variety of products is available in a number of current publications. This information is generally in terms of yearly unit or dollar volume sales or factory shipments. Other publications not specifically related to marketing often have articles on product trends and estimates on future product sales that are helpful in making unit or dollar-volume estimates for the analysis.

At the completion of Step 4 or during Step 5, you must accurately determine product costs, using a detailed study of manufacturing processes and material costs. A comprehensive market survey can be conducted through the company operation or by hiring a market-survey.

Success of the new-product analysis program will be measured by management in terms of the dollars income resulting from the program and the cost of operating it. The 7-step analysis system is somewhat like the Seven Falls tourist attraction at Colorado Springs; a lot of water had to come from the little spring above before the first drop fell into pool below. The system is greedy for new ideas; this sparks the search for new ways of coming up with them. The uniform method of handling such analyses is inherently economical and the quality of the new-product ideas is maintained by considering its whole life in each step analysis. This type of analysis speaks management's language—in dollars and time. Result is an aura of clarity and understanding in the discussion of new products with management.

TYPICAL PRODUCT ANALYSIS

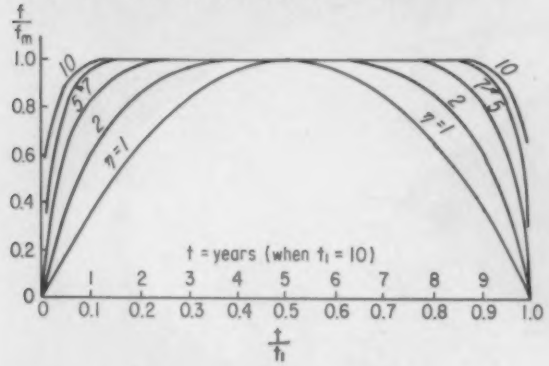
Analysis of a new product based upon this technique requires certain factors to be estimated and others to be calculated. Accuracy of the estimates depends on the experience of the estimators and the amount of supporting information available.

The summary sheet shows an analysis for product X that follows the *a* and *b* concept, with additional informa-

tion required to complete the analysis. Selling price, p, is estimated to be $1.50. Maximum expected volume, V_m, is estimated to be 1,300,000 units per year. Maximum yearly dollar volume, f_m, is then $1.50 x 1,300,000, or $1,950,000.

Acceleration time, t_a, then completes this segment of the analysis by telling how long it will take to reach maximum production. For product X, it was estimated that maximum production would be realized two years after start of production. To simplify calculations the rate of production increase might be considered linear; or you could use a more representative curve of actual rate increase based on past experience.

For this analysis, the curves shown here



were derived from the expression:

$$\frac{f}{f_m} = 1 - \left(1 - \frac{2t}{t_1}\right)^n$$

where: f = Dollars at any time t
f_m = Maximum estimated dollars income
t_1 = 10 years
n = 2

As n is varied, a family of curves is produced; f_m occurs at the midpoint of the curve in all cases and acceleration time based on f_m is always $t_1/2$. Because the slope of the curve increases as n is increased, acceleration time should be estimated on the basis of reaching some percentage of f_m. Using 90%, this point occurs at $t = 2.3$ years on the $n = 2$ curve, which is nearest the 2-year acceleration time estimate for product X. When using a family of curves, estimates of acceleration time are determined independently of the curves. Then a curve is selected which is closest to the 90% f_m value at the estimated acceleration time.

The next segment of information is product expense a throughout product life. For product X it was estimated that $50 should cover the step-1 preliminary analysis; $250, the cost of developing a "paper approach" and preparing a step-2 analysis; and that $2500 would be enough to cover cost of laboratory exploratory work—to verify the "paper approach" and make a step-3 analysis. Based upon past experience with similar products, the research-and-development cost a_4 was estimated at $35,000.

The $108,916 shown in a_5 is broken down on another sheet of the analysis and consists of tooling costs, preproduction costs, formal market-survey cost, and interest on risk. The sum of a_1 through a_5 is the maximum risk and is $146,716. This amount is entered as d on the bottom line of the analysis summary sheet.

The expense during the breakeven period is a_6. It is calculated to be $1,891,169 when related to the risk and the anticipated net profit. In the case of product X, a 15% net profit before taxes was used with a 52% tax rate. The percent net profit after taxes is then 48% of 15% or 7.2%. At this rate, $a_6 = 12.89d$ or $1,891,169. The amount for a_7 was calculated from b_7 as $9,963,429 and is the expense during the remaining production time. The sum of a_1 through a_7 is the total expense and is equal to $12,001,314.

Income dollars from product X are listed in the b section of the analysis summary sheet. Since this product will be supported only by the company, no income is expected until production begins and the amounts for b_1, b_2, b_3, b_4, and b_5 are zero. (Income before b_6 is possible in the case of government contracts or other external support.) Income dollars required to break even were calculated to be $2,037,885 and were entered for b_6. This amount is the sum of a_6 and d. Income during remaining production time after the breakeven point was then calculated to be $10,736,454; this amount was entered as b_7. The sum of b_6 and b_7 is then the total income b of $12,774,339. The difference between a and b is $773,025—entered on the bottom line of the analysis sheet as the net gain c. The net gain-to-risk ratio, or c/d, is 5:1.

The times associated with each phase of the product are listed in the t section of the analysis summary sheet. t_1, t_2, and t_3 have been lumped together and estimated at 0.2 year. The R & D program was estimated to take 1 year; tooling and product engineering time, 0.5 years. Product life was estimated at 10 years. Breakeven time t_6 was calculated from the breakeven dollars b_6 and found to be 1.9 years. This leaves a remaining production time t_7 of 6.4 years. The exact method of calculating a_7, b_7, and t_6 has been purposely omitted because of their dependence upon the type of production curve that might be used.

Analysis of product X as summarized on the sample form is based upon estimates guided by economically available information and past experience, with certain assumptions made to simplify calculations. It states that if you start now on this product, you can expect a net financial gain of $773,025 in 10 years at a risk of $146,716 and a gain-to-risk ratio of 5:1. Now apply the acceptance criteria: gain-to-risk ratio required, estimated dollar volume limit, and breakeven time limit. Should product X be advanced to the next step?

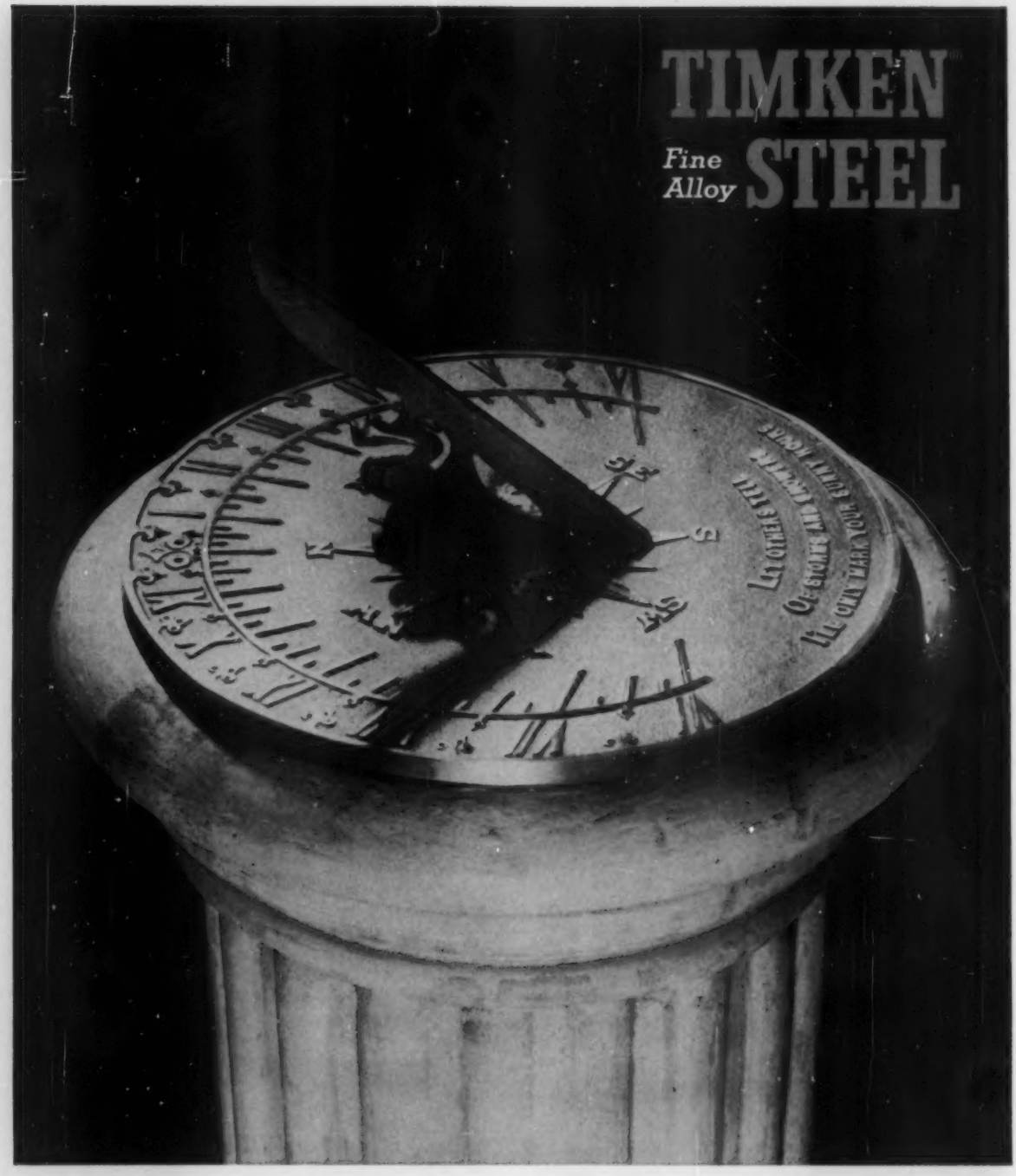
EDITOR'S NOTE: For more on choosing profitable new products see:

The Yardsticks for Research Success, Oct 19 '59, p 34. Discusses three indices of new-product profitability: return on total sales, return on investment, and cash flow.

How Effective Are Committees in Product Planning? July 27 '59, p 36. Points of view of four top management men on benefits and pitfalls of committee planning for new products.

A Dollars-and-cents Evaluation of New Products, June 29 '59, p 21. Offers a system based on four parameters: average development cost per year, years of development time, average profit per year of product life, and years of market life.

The Economics of Research and New-product Planning, March 9 '59, p 42. Stresses importance of objective analysis. Article shows how three different companies tackle the problem.



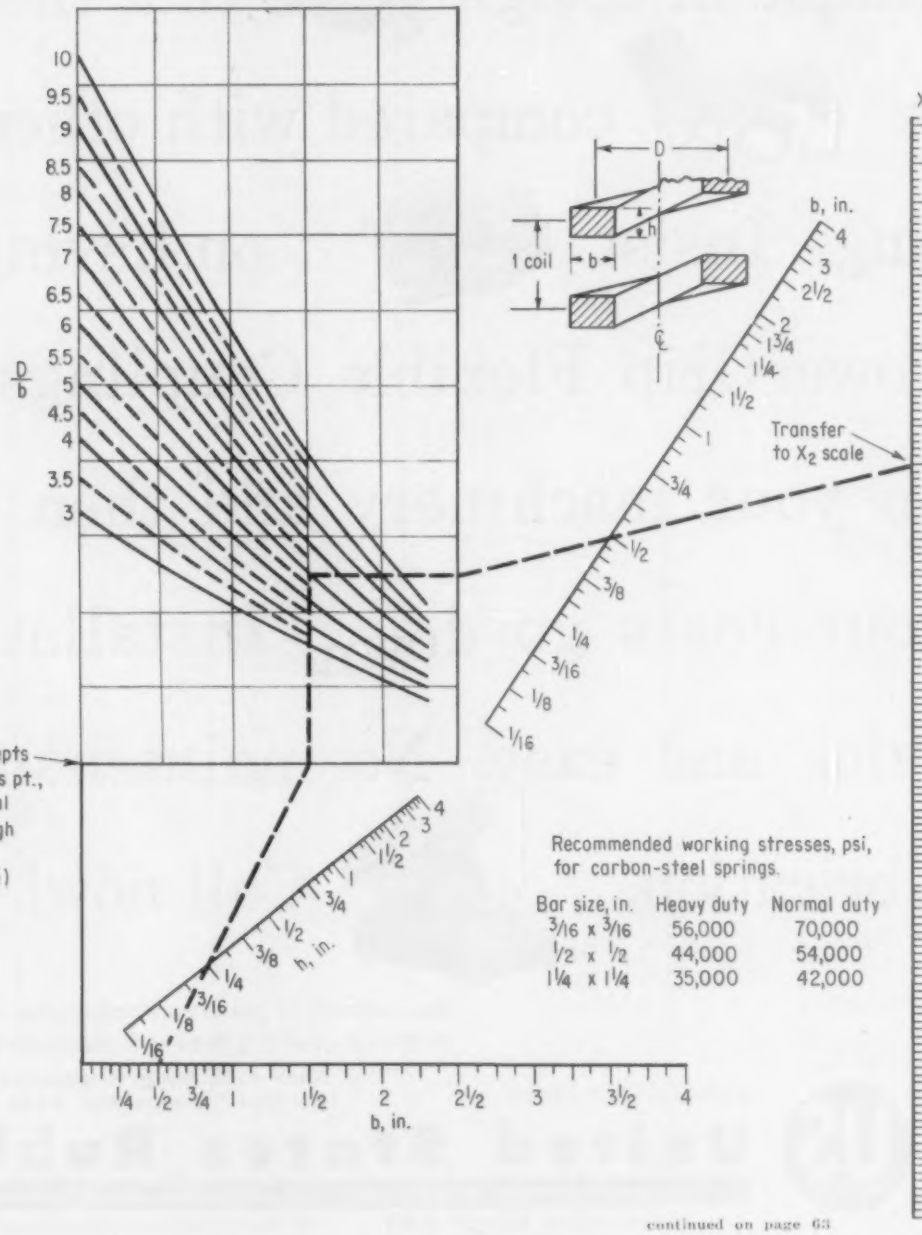
SUN TIME or any time is the time to order your Timken® 52100 steel tubing. It will be shipped within 24 hours of the time we receive your order. We carry 101 sizes in stock—from 1″ to 10½″ O.D., in a wide range of wall thicknesses, to make this speedy service possible for less than mill quantities. And remember, 90% of the structural parts that can be made from seamless tubing can be made from either of the two Timken grades—52100 and 4620. The same service is available on 50 sizes of 4620 tubing. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

for rectangular sections, nomographs find . . .

FIBER STRESS IN HELICAL SPRINGS

These aids are for 1-in. to 30-in. mean coil dia with 1/16-in. to 4-in. bar section, and for axial load from 1 to 30,000 lb. A similar set of charts, for spring stiffness, appeared in the Apr. 25 issue.

J F WATERS
Westerham, Kent, England

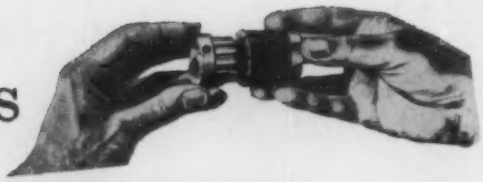
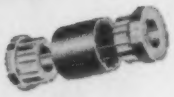


Recommended working stresses, psi, for carbon-steel springs.

Bar size, in.	Heavy duty	Normal duty
3/16 x 3/16	56,000	70,000
½ x ½	44,000	54,000
1¼ x 1¼	35,000	42,000

continued on page 63

US RUBBER **PowerGrip** FLEXIBLE COUPLINGS

These couplings  are so simple in design  that their cost is compared with other couplings. Insist on having U.S. PowerGrip Flexible Couplings tried on your machinery and then watch your costs go down. Installation is quick and easy. No maintenance, no lubrication. Call now!

The only way to get expert transmission engineering is through your U.S. Rubber Transmission Distributor.

"Visit Booth 1324, Design Engineering Show, New York Coliseum, May 23-26."

US RUBBER Mechanical Goods Division

United States Rubber

WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

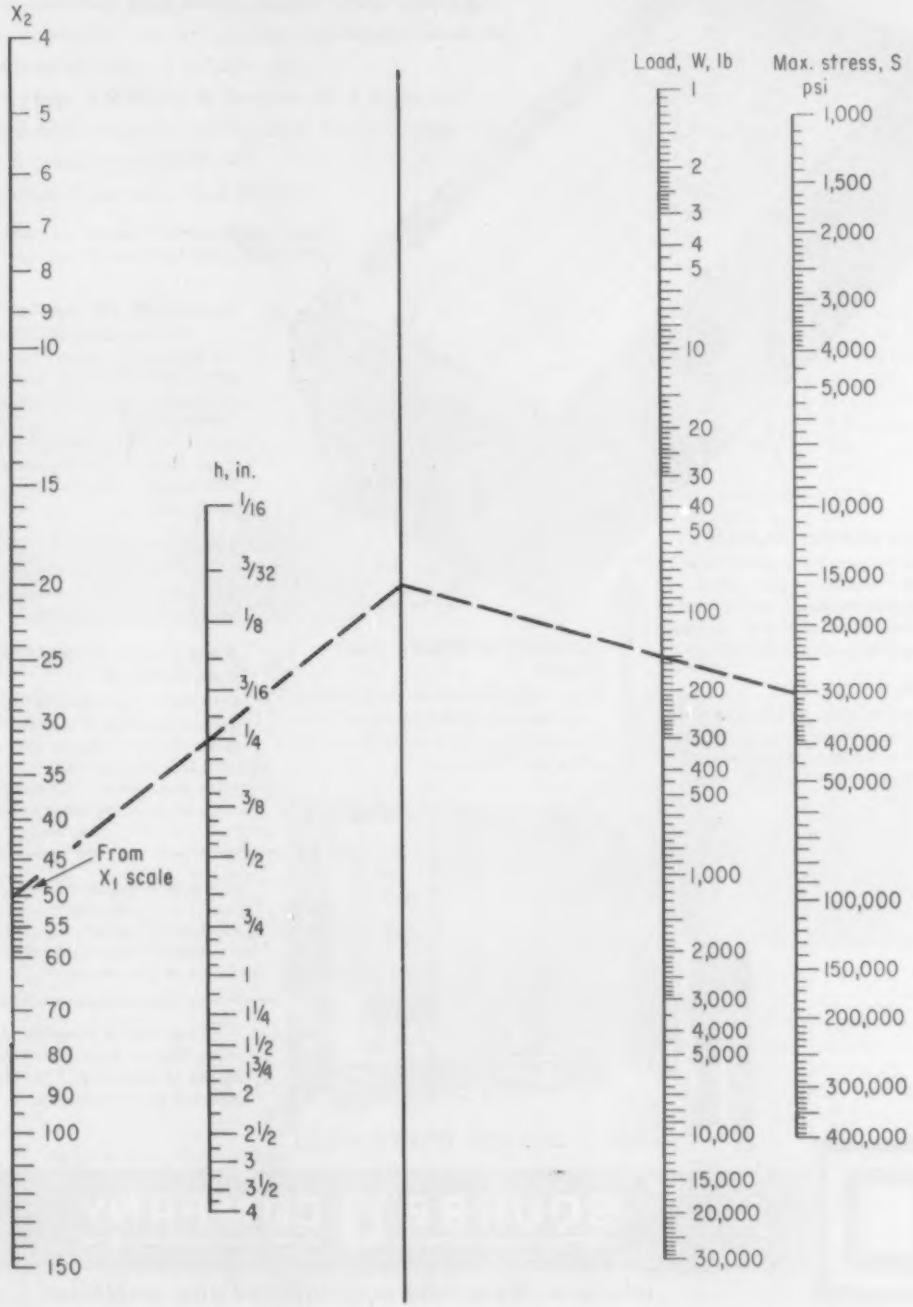
Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Maximum permissible fiber stress for rectangular-section springs can be calculated from

$$\text{Max stress} = \frac{\lambda W(D + b)(b + h)}{b^2h^2}$$

where λ is a factor dependent upon values of b/h and D/b. The nomographs presented here solve this equation quickly—the small chart combined with the nomograph below incorporates the λ factor.

Example: A spring has $b = \frac{1}{2}$ in.; $h = \frac{1}{4}$ in., and $D = 3$ in. What is max fiber stress when a 150-lb load is applied? Procedure: Join known quantities by secants. Answer is revealed as max stress of 30,000 psi.



SQUARE D announces NORpak

—A SIMPLER, FASTER, STATIC CONTROL!

NORpak is a significant advance in the field of static switching. Like other static systems, **NORpak** performs the functions of machine tool relays, stepping relays, latching relays and timers —all without contacts or motion of any kind. Like other static systems, **NORpak** is ideal for applications where speed is important—where reliability and long life are essential—where conditions make conventional magnetic devices impractical.

But unlike other static switching systems, NORpak offers these important advantages

EASIEST TO APPLY

The transistor NOR unit is the basis of **NORpak.** All logic functions—AND, OR, NOT, MEMORY—can be accomplished with combinations of this single NOR unit.

NORpak is *not* complicated — it's easy to apply to conventional circuits. Units are color-coded for quick identification. Simple DC circuit eliminates worry about phase relationships.

EXTRA DEPENDABILITY

NOR units have been time-tested in computer use for years. They are not subject to wear, will give top performance indefinitely, and provide unfailing circuit fidelity.

SIMPLE TO USE

Optional monitor lights give visual evidence of proper performance. Simple dynamic sequence tester checks individual NOR units in operation.

UNMATCHED SPEED

NORpak provides switching at rates up to 25,000 per second — faster than any other industrial static system.

EXPERT APPLICATION HELP

Field specialists, factory-trained in all aspects of **NORpak** can give you on-the-spot answers to any application questions.

SMALLEST COMMERCIAL PACKAGES

NORpak is available in the form of individual components, or in completely engineered systems. Components are offered in 6 and 20 paks, require only 1/4th the equivalent relay panel space, and weigh less than components of other static systems.

NORpak is available as individual components for application to specific control functions, or as completely engineered systems ranging from the smallest to the largest panels

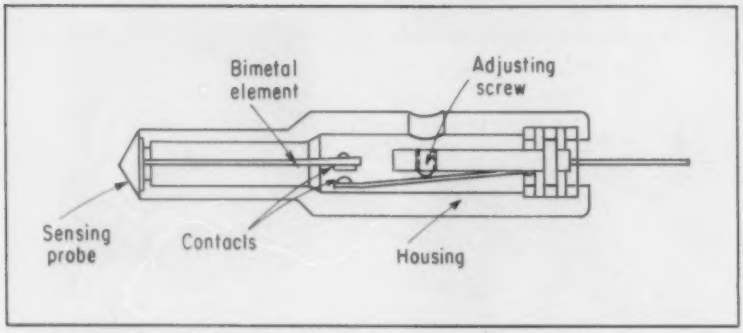
Write for the complete story on **NORpak** *— its theory, application and operation... Square D Company, 4041 North Richards St., Milwaukee 12, Wisconsin*

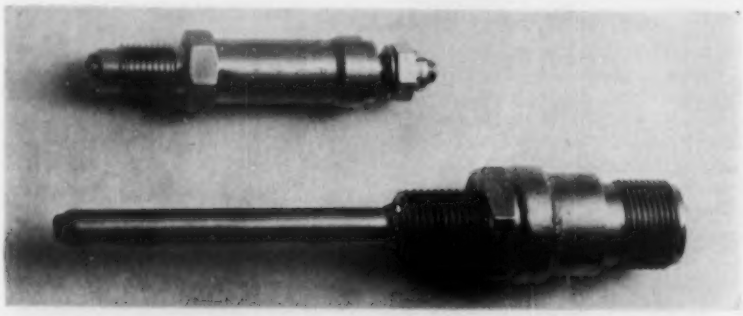
...design leadership

SQUARE D COMPANY

wherever electricity is distributed and controlled

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES





Thermal switch responds in less than 0.5 sec . . .

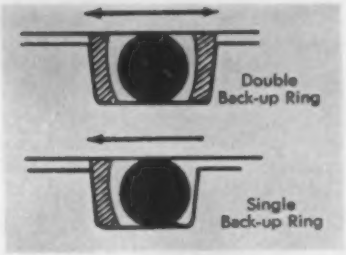
because high-continuity thermal element is joined with sensing probe directly, rather than through a protective shell. Operates within — 20 to 550 F. Employs spring-loaded inner cartridge that is hermetically sealed. Slow make-and-break operation is based on thermal bimetal principle. Reaction time is said to be less than 0.5 sec; temperature differential, from 1 to 2 degrees; repeatability of operation, 1 F. Weighing 0.9 oz, switch has over-all length of 2.5 in. and diameter does not exceed 0.5 in. Probe has possible compression of 0.036 in. Single-lead unit is rated 1.5 amp at 28 v dc and 115 v ac resistive. Meets requirements of MIL-S-25345 Amendment 2. Reported to be most effective where inner temperature must be controlled. Also used to measure bearing temperature. It is supported in bearing housing and thus pressed against bearing race or shell. Sells for $37.50 in lots of 1 to 25. Delivery, 8 to 10 wk. **Control Products Inc, 306 Sussex St, Harrison, NJ.**

Circle 300 on Reader Service Card

Diecastings of 99.99%-pure aluminum . . .

alloy are said to have permanently lustrous high finish, whose reflectivity exceeds that of chrome. Finish is achieved by anodizing process. After anodizing, castings can be dyed to simulate gold, silver, platinum or brass, as well as a complete range of colors. Castings, fabricated by Nelmor Mfg Corp, Euclid, Ohio, are said to be highly corrosion-resistant. **Fromson Orban Co Inc, 261 Madison Ave, New York 16.**

Circle 301 on Reader Service Card



Continuous backup rings . . .

for O-ring-in-groove installations are reported to increase O-ring life and to cost up to 50% less than conventional types. Designed with concave shape to prevent O-ring extrusion and increase lubrication of O-ring. One-piece rings are said not to cut O-rings due to improper installation or worn backups. Molded of compound said to be resistant to most fluids, gases and air. Can be used in all standard pressure systems in temperatures from — 85 to 350 F. Available in standard sizes, 0.029 to 15.475 in I.D. Priced from $23.30 to $437 per 100 for this range of sizes. About 3-wk delivery. **Parker Seal Co, Dept BR-1, 10567 Jefferson Blvd, Culver City, Calif.**

Circle 302 on Reader Service Card

Meter relay is driven by low-level signals . . .

or the output of differential transformers, strain gages, gas analyzers, bridges, temperature-sensitive elements or photocells. Signals as low as 2 microw activate unit, which can sort, grade or classify, alarm, indicate or control. Operation is continuous, without need for reset circuitry. Current application automatically classifies close-tolerance products made by machine tools. Tolerance class is shown on one of five indicator lamps on instrument panel. Device can

continued on page 66

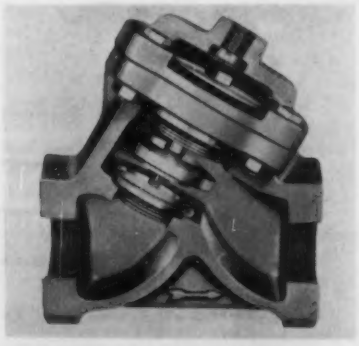
perceive 0.000,05-in. change in thickness (illustrated) on basis of less than 2-microw signal change from gaging head. In addition, output power can be fed back to machine tool to correct deviation from nominal tolerance before reject class is reached. Output is available for sequential operation of up to nine power relays or for stepless control of up to 600 w. Price, about $150 to $500. Delivery, stock to 6 wk. **Electric Regulator Corp, Pearl St, Norwalk, Conn.**

Circle 303 on Reader Service Card

Nickel-silicon bronze alloy . . .

is said to equal ductility of 2% silicon and to have superior ductility to 3% silicon bronze in ordinary hard-drawn state. By proper aging, alloy is reported to develop higher tensile strength than 2% silicon bronze. Has 30% min conductivity for normally age-hardened material. Currently available in round rod and wire only. Material ranges from 0.062 to 1½ in. long and 0.062 to 0.625 in. coils. **Bridgeport Brass Co, Bridgeport 2, Conn.**

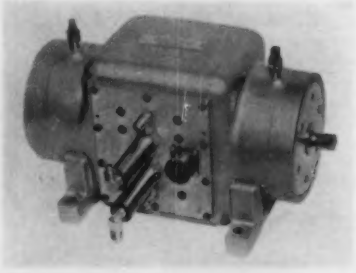
Circle 304 on Reader Service Card



Power-operated diaphragm valve . . .

has diaphragm actuator that works directly off actual line pressure and functions positively in both directions without use of springs or other auxiliary forces. Diaphragm, which is neoprene reinforced with nylon, is attached to solid stem shaft that slides through hole in solid barrier plate and carries valve disk on its lower end. O-ring in shaft hole holds against pressures far in excess of rated pressures. Line pressure, applied above diaphragm through ¼-in. line and manual or powered control valve, forces diaphragm, stem and disk down to close valve on seat. Disk is held closed because area of line pressure on diaphragm is larger than area of line pressure against disk and seat. When pressure is removed from above diaphragm, pressure in line against disk pushes it up to wide-open position. Servicing is facilitated by valve cap, which, when removed, permits working parts to be replaced without removal from line. Now available in three groups: in ¾- and 1-in. sizes; in 1¼- and 1½-in. sizes; in 2- and 2½-in. sizes. All are screw-type with cast-iron bodies, hot-dip galvanized in sizes under 1½ in. Prices range from $20.45 to $56.88 each. From stock. **Aquamatic Inc, 2412 Grant Ave, Rockford, Ill.**

Circle 305 on Reader Service Card



High-speed torque meter . . .

is capable of transmitting torque signals through 50,000 rpm. Bearing arrangement is coupled with no-noise, long-life slip-ring assembly. Model is being built in ranges from 0 to 100 in.-lb full scale through 0 to 1000 in.-lb full scale with 0.6-pitch-dia male-spline shaft ends. Larger versions, with 0.8-pitch-dia male-spline shaft ends, transmit torque through 2500 in.-lb full scale; with 1.2-pitch-dia splines will cover ranges up to 10,000 in.-lb full scale. Instrument is usually furnished with coupling halves on shaft assembly. **B & F Instruments Inc, 3644 N Lawrence St, Philadelphia 40.**

Circle 306 on Reader Service Card

10,000-psi hydraulic valve . . .

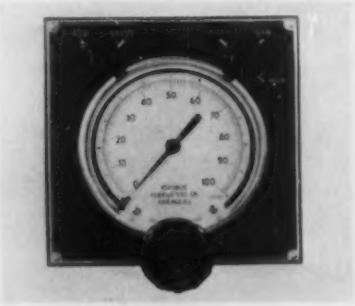
is free-flow metering unit for systems that require ram pressure to be maintained after po er has been turned off. In operation, moving valve control holds ram pressure in clockwise direction. Valve also functions to control speed of ram return by allowing oil to return either free or at internally adjusted rate as control handle is turned counterclockwise. **Greenlee Tool Co, Rockford, Ill.**

Circle 307 on Reader Service Card

Flexible tube couplings . . .

are mechanically attached without flare or beads and are reported to offer low weight-to-strength ratio. Couplings are attached to tubing by swaging method. so that fittings literally become part of tubing. Pressure capacity is up to and over burst value of tube, with ¼-in. axial motion and up to 8° angular flexibility. Available in ⅜- to 5-in. sizes for temperatures from —70 to 450 F. Approved to MIL-C-25104 specification. **Gamah Corp, 1654 Lincoln Blvd, Santa Monica, Calif.**

Circle 308 on Reader Service Card



Pneumatic control stations . . .

for transfer between automatic and manual operation as well as for set-point loading and manual loading are said to be accurate within 1% of full scale. Controlled variable is indicated on automatic and manual operation. Input and output ranges vary from 3 to 15 psig, with air consumption of less than 0.2 scfm. Red outer pointer indicates manual loading pressure; black center pointer indicates automatic loading pressure. Control stations are for standard panel mounting in 5¼ sq in. cutouts or space. **Republic Flow Meters Co, Sub of Rockwell Mfg Co, 185 N Wabash Ave, Chicago 1.**

Circle 309 on Reader Service Card

Self-locking wingnuts . . .

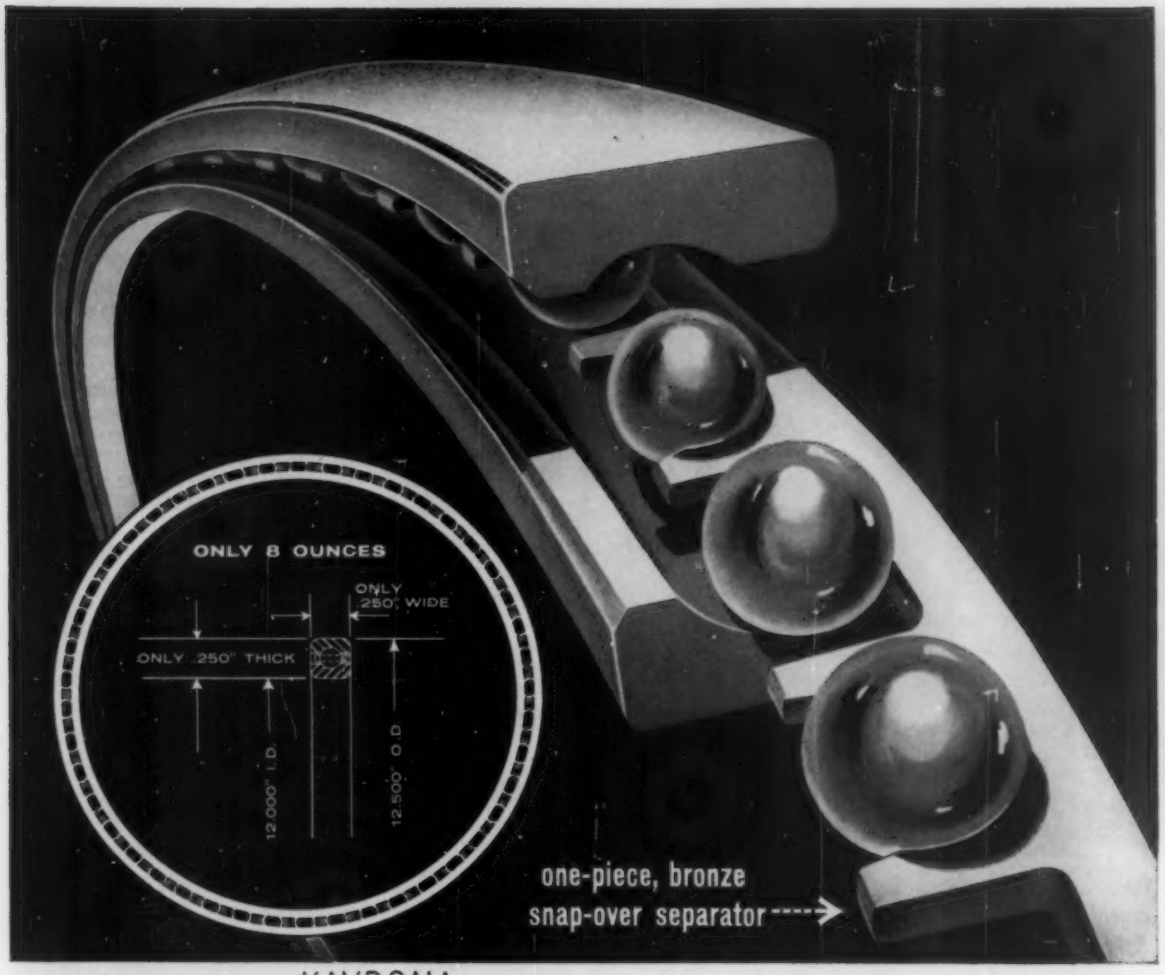
made of Zamak 3 die-cast alloy, are available in thread sizes No. 8, 10, ¼, 5/16 and ⅜ in coarse and fine threads. Nylon locking collar prevents loosening under impact, vibration or stress reversal, whether fully seated or not. **Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.**

Circle 310 on Reader Service Card

Miniature insulated screw . . .

consists of metal screw with shank insulated with thin integral cladding of Mylar polyester film, which offers high (up to

continued on page 68



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

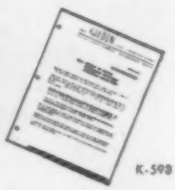
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.

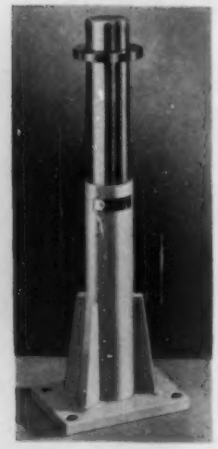


THE KAYDON ENGINEERING CORP.
MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearing

10,000 v) dielectric strength per mil and high thermal conductivity. Can be operated at temperatures to 266 F. OD of insulation is said to be no greater than OD of thread. Standard sizes include all screw sizes from No. 1 up; length of shank and insulated section to specifications. Various metals are available. Heads may be Phillips or slotted. **Pylon Co Inc, 200 N Main St, Attleboro, Mass.**

Circle 311 on Reader Service Card



Two-way time-delay liquid spring shock . . .

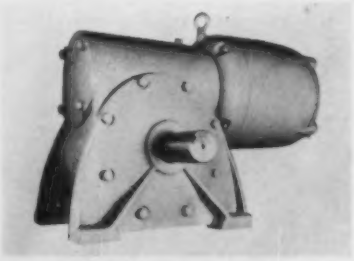
operates in one direction creating compression by striking ball and piston cap; in the other direction, a forked device picks up flanges on tension piston to absorb both shock and impact with subsequent time delay. After absorbing shock force, liquid spring provides 4000-lb output over 1-in. stroke. Shock provides 13,000-lb shock resistance on flat-topped energy curve at any impact velocity below specified 90 in. per sec. Mounting base is 6 x 4 x ½ in. with liquid spring shock extending above base 16 x 1⅞ in. dia. **Taylor Devices Inc, 188 Main St, N Tonawanda, NY.**

Circle 312 on Reader Service Card

Two-color indicator light . . .

is white when unlit and colored when lighted. Subminiature panel indicator light accepts No. 327 and 328 bulbs, mounts in ⅜-in.-dia hole and is available in red, white, blue, green and amber. Front-bulbing unit is said to meet or exceed all applicable military specifications. **Sloan Co, 7704 San Fernando Rd, Sun Valley, Calif.**

Circle 313 on Reader Service Card



Aluminum-housed worm gearmotor . . .

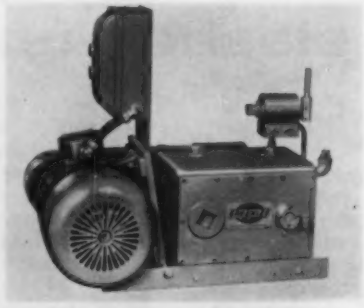
has 6-in. center distance. Available in 3-, 5-, 7½- and 10-hp units, foot-mounted, ring-mounted or shaft-mounted. **Electra Motors Inc, 1110 N Lemon St, Anaheim, Calif.**

Circle 314 on Reader Service Card

Sealed subminiature switch . . .

measures 0.616 x 0.6 x 0.316 in.; weighs 0.2 oz. Switch mechanism and extending lead wires are embedded in epoxy resin inside a treated corrosion-resistant, aluminum housing. SPDT switch operates in ambient temperatures of −65 to 230 F. Rated 4 amp inductive, 28 vdc; 5 amp at 115/230 v, 60 cps, ac. **Micro Switch, Freeport, Ill.**

Circle 315 on Reader Service Card



High-pressure power pumps . . .

are designed to speed operation on hydraulically activated equipment. One of two units features radial-type pump with two diametrically opposed pistons driven by eccentric drive shaft. Pump is equipped with V-belts, pulleys, belt guard and motor mounting frame, but without motors, controls or hose. When powered by 3-hp, single or polyphase, 60-cps motor, pump delivers 213 cu in. per min. oil at 10,000 psi. With 2-hp motor, pump delivers 106 cu in. per min. Second unit is identical to first, but includes auxiliary low-pressure pump which provides delivery of 5 gpm of oil up to 800 psi and automatic changeover to 213 cu in. up to 4500 psi and 106 cu in. up to 10,000 psi. **Greenlee Tool Co, Rockford, Ill.**

Circle 316 on Reader Service Card

Miniature pressure switch . . .

originally designed for Polaris program is 1 x ¾ in. dia. Weighs 2 oz. All-metal unit can be factory-set from 30 to 500 psi gage or absolute. **Century Electronics & Instruments Inc, 1333 N Utica, Tulsa, Okla.**

Circle 317 on Reader Service Card

Shaft-position encoder . . .

provides 1200 positions in 320° revolution in binary-coded decimal code, which is not ambiguous without mechanical anti-ambiguity devices or double-brush systems. Nominal readout speed is 60 rpm, but max of 200 rpm and higher is possible with readout equipment. Operates under ±8 g to 1000 cps and withstands 100 g steady state in any axis. Uses 3½ in. disk. Housed in case about 2 x 4 x 5 in. Life expectancy is about 5 yr. **Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.**

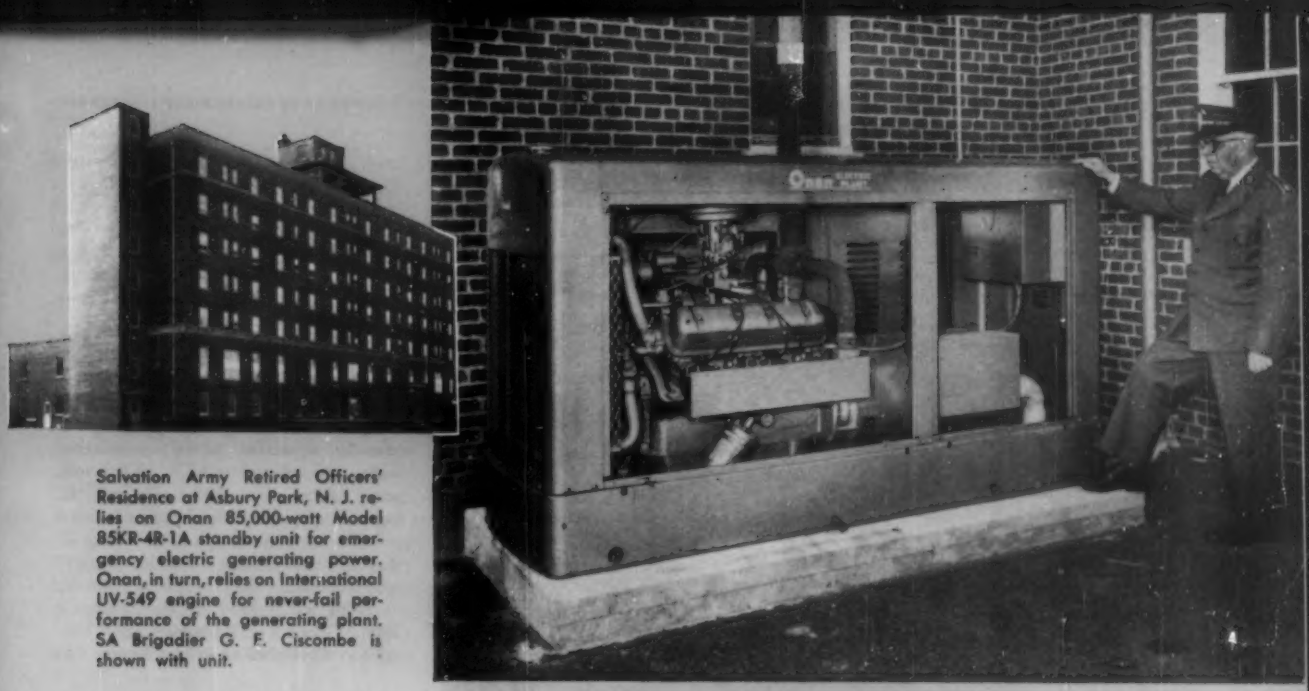
Circle 318 on Reader Service Card

Synchronous differential . . .

combines two hysteresis synchronous motors and mechanical differential in 3⅛-in. housing. Can be used for automatic synchronization of machinery or as means of regulating frequency of two supplies. One synchronous motor is connected to control or master frequency; the other to supply that is to be controlled. Where two frequencies synchronize, output shaft of device remains stationary. As one input frequency changes with respect to the

continued on page 70

CIRCLE 69 ON READER SERVICE CARD→



Salvation Army Retired Officers' Residence at Asbury Park, N. J. relies on Onan 85,000-watt Model 85KR-4R-1A standby unit for emergency electric generating power. Onan, in turn, relies on International UV-549 engine for never-fail performance of the generating plant. SA Brigadier G. F. Ciscombe is shown with unit.

D. W. ONAN, a leading producer of air-cooled engines, chooses INTERNATIONAL®

WHEN SPECS CALL FOR WATER-COOLED POWER

Report from Vice President-Engineering, J. C. Hoiby, D. W. Onan & Sons Inc., Minneapolis, Minn.

V.P. Hoiby says, "Onan equipment is built for 100% dependability. That's why we have chosen International gasoline engines to power our 60 kw and 85 kw standby generating plants. With such a dependable power source Onan customers need never worry about power outages. International also gives us the advantages of an excellent parts and service organization."

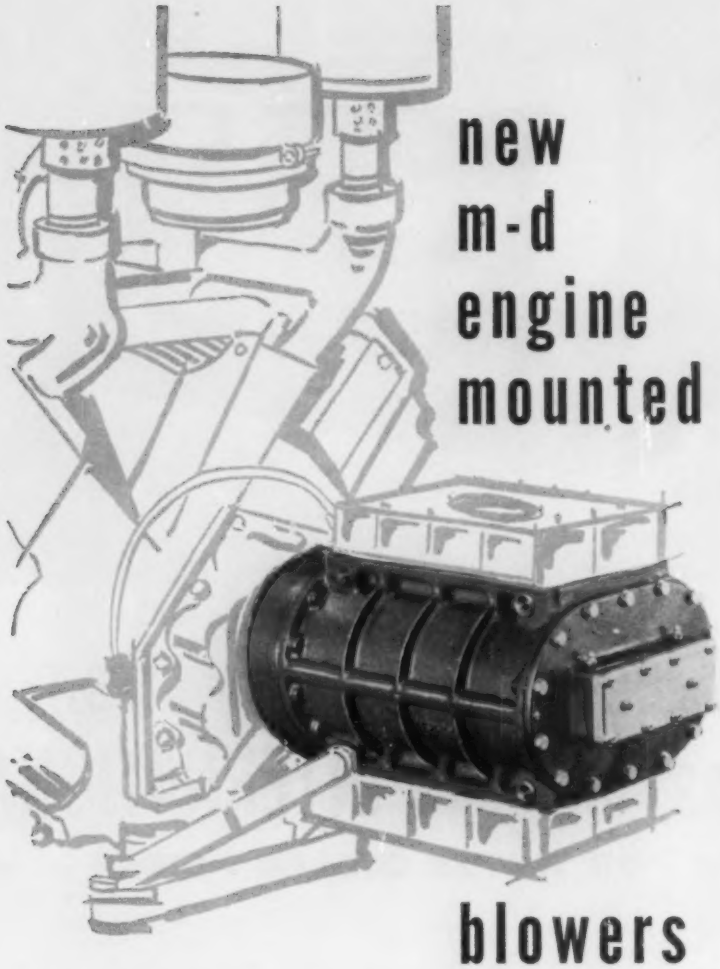
Here's another major manufacturer who knows the built-in benefits of International power. D. W. Onan & Sons Inc., producers of a famous line of air-cooled engines and heavy-duty generating equipment, rely on an International gasoline engine for this 85,000-watt standby electric plant. In case of commercial power interruption, this unit cuts in automatically and supplies power for the entire Salvation Army building. In addition to furnishing standby power for all lights in the building, the plant also serves laundry equipment, elevators, oil burner, water pump, and electrical cooking.

If you haven't joined the long list of International power users, you may be passing up an extra selling advantage for your product. So learn all about the IH line—35 engines from 16.8 to 385 max. hp—with choice of fuels, and interchangeability in size and power, to match your requirements. For detailed information contact International Harvester Co., Engine Sales Dept., Construction Equipment Div., Melrose Park, Ill.

INTERNATIONAL®
ENGINES

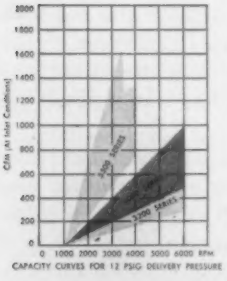
International Harvester Co.,
180 North Michigan Ave.,
Chicago 1, Illinois

A COMPLETE
POWER PACKAGE



new m-d engine mounted blowers

weigh only 625 lbs. Provide 400 SCFM continuous air flow



M-D answers the need for lightweight pneumatic units for vacuum or high pressure systems. Only 625 lbs. total weight of blower *and* engine. Dependable M-D units generate 15 PSIG of continuous air flow or up to 18 PSIG in surges. Ideal for mobile applications. M-D muffler packs mean quiet operation.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN

A SUBSIDIARY OF MIEHLE-GOSS-DEXTER, INC.

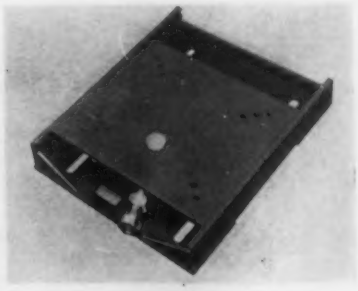
other, output shaft rotates at speed equal to one-half the difference in speed of the two synchronous motors. Motors are each 400 cps, 115 v units with total power input of 15 w max. Synchronizing torque is 0.45 in.-oz min; speed, 6000 rpm. Device weighs 26 oz. **Kollsman Motor Corp, Dublin, Penna.**

Circle 319 on Reader Service Card

Sequential time-delay relay . . .

provides sequential time-delay switching within tolerance of ±0.2% or ±1 millisec. Energizes at 100, 250 and 450 millisec. Operates on nominal 28-v-dc power source; switches up to 1 amp dc; and operates in similar manner to 3PST relay. Measures 3 x 3 x 6 in. and has operating life of 1000 hr. **Hydro-Aire Co, 3000 Winona Ave, Burbank, Calif.**

Circle 320 on Reader Service Card



Pancake motor base . . .

for use in variable-speed sheave installations where it is necessary to vary center distance between sheaves with pitch-diameter changes. Base is 1⅞ or 1⅝ in. high, depending on NEMA motor-frame number. Movement of 4½ or 6 in. also depends on NEMA motor-frame number. Top plate of motor base is drilled to accommodate various combinations of NEMA motor frames. Can be used with any V-belt drive. **T B Wood's Sons Co, 1200 Fifth Ave, Chambersburg, Penna.**

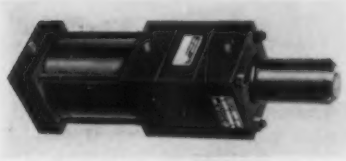
Circle 321 on Reader Service Card

Precision components . . .

that may be assembled into servo and instrument mechanisms include gears, shafts, ballbearing gearboxes and component mounting plates. All standard miniature rotating-shaft components are said to be suitable for mechanisms meeting MIL-E-5400. Various mechanisms can be assembled from stock components. Production quantities are available from stock or with short lead times. **Precision Mechanisms Corp, 577 Newbridge Ave, East Meadow, NY.**

Circle 322 on Reader Service Card

continued on page 71



Air-hydraulic boosters . . .

Boost ordinary compressed air (80 psi) up to 3000 psi hydraulic pressure, without use of additional power or need for pumps or motors. As pressures increase, effectiveness of multiple-lip self-energizing seal is also said to increase. Booster ties into any air line and requires no complicated piping, valves or controls. Strokes up to 200 cpm. Unit is interchangeable in regard to fluid systems. Standard intensified fluids are petroleum-base oil and water-base fire-resistant fluids. **S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.**

Circle 323 on Reader Service Card

Automatic clutches . . .

for gasoline engines, 1 to 100 hp, offer full 360° effective friction surface with wear distributed evenly over entire lining area. **Salsbury Corp, 1161 E Florence Ave, Los Angeles 1.**

Circle 324 on Reader Service Card

Miniature epoxy-coated motor . . .

is hysteresis-synchronous unit, 1¼ in. dia. Motor develops ¾ in.-oz torque at 1800 rpm synchronous speed. Normally wound for 110 v ac, 60 cps. Mounted by clamp around motor OD. Weighs 7 oz. Recommended for miniature recorders, timers, computers and similar industrial uses. Costs about half as much as comparable military motors in production quantities. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 325 on Reader Service Card

Industrial pipe insulation . . .

is fabricated of urethane foam. Constructed with longitudinal seam that allows it to spread open to receive pipe and, upon release, to snap back to enclose pipe. Insulates from —300 to 275 F. Offers low K factor and longevity. **American Cellular Co Inc, New Castle, Del.**

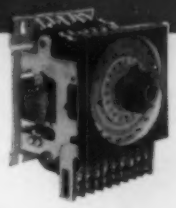
Circle 326 on Reader Service Card

Quartz-crystal pickup . . .

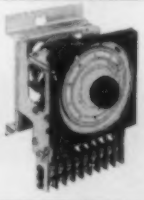
measures variations of 0.1 psi throughout rated range of 5000 psi. Special models cover 10,000 psi range. Pickup has natural frequency of 100,000 cps, a 5-micro-

continued on page 72

Count Control
COMPONENTS
FOR AUTOMATING INDUSTRIAL PROCESSES
featuring
adjustable count
automatic reset
10 ampere switches

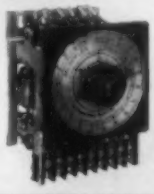


model HZ4
MICROFLEX RESET COUNTER
Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.
Ask for bulletin 720.

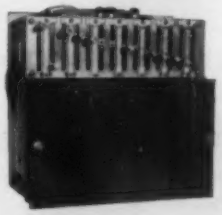


model HZ200
ADD-SUBTRACT COUNTER
Add-Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.
Ask for bulletin 740.

model MT
STEP SWITCH
Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.
Ask for bulletin 780.



model HZ6
MICROFLEX REVOLUTION COUNTER
Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.
Ask for bulletin 730.



model HM
MULTIFLEX (Multiple Circuit) TIMER
Use for sequence control of 1 to 7 circuits. With shaft drive for mechanical connection to an external drive mechanism.
Ask for bulletin 130.

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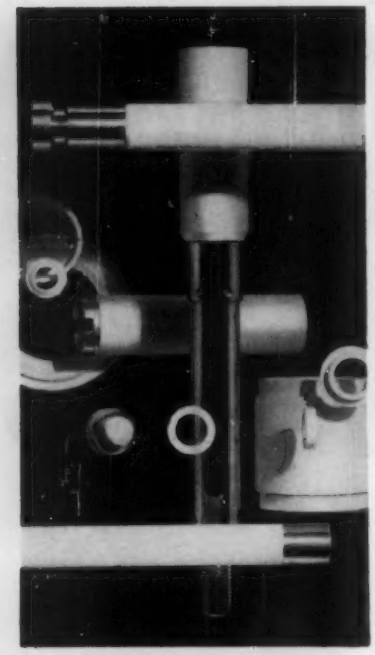

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sec rise time, and sensitivity of 200 milliv per psi when used with 1-ft cable. Reported to withstand temperatures of —400 to 500 F without loss of accuracy. Dimensions are about 1 x 1 in. dia. **Kistler Instrument Corp, 15 Webster St, N Tonawanda, NY.**

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are available in over 1000 ratios, from 5:1 to 78,125:1. Stock ratios range from 5:1 to 2000:1 and all ratios are designed to max recommended load torque of 100 in.-oz. Max backlash is reported not to exceed 30 min. as measured with 1 in.-oz load on output shaft. No-load speed is 6700 rpm and torque at stall is 0.63 in.-oz. Operating temperature range is from —65.2 to 248 F. **Guidance Controls Corp, 110 Duffy Ave, Hicksville, NY.**
59—30

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for neon or incandescent replaceable lens and lamps is nonsnap, normally open, momentary-contact unit rated ½ amp, 115 v ac. Contacts are reported to have life expectancy of 1 million cycles. Lamp leads and switch terminals are brought out separately in four-pin base socket, allowing use of switch and light, independently or in combination with each other. **Eldema Corp, 1805 Belcroft Ave, El Monte, Calif.**

Circle 329 on Reader Service Card

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in grade G-7 is now available in sheet size of random 24 x 36-in. in thicknesses from ¼ to 2 in. **Synthane Corp, Oaks, Penna.**

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Circle 331 on Reader Service Card

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Circle 332 on Reader Service Card

Oil flowmeter . . .

measures rate of flow in hydraulic systems with pressures up to 1500 psi and with any viscosity oil. Provides immediate visual indication of pump condition and degree of wear under all operating conditions. Price is $79.50. **Perma-Weld Co Inc, 1947 N Topeka Blvd, Topeka, Kan.**

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is based on standards registered by manufacturers with JEDEC. Has cutouts for 27 sizes of transistors, using registered designating numbers, sizes and specifications. Outlines are of top view and side elevation. Templet size is 9½ x 5½ in. Priced at $3. **Rapidesign Inc, PO Box 429, Burbank, Calif.**

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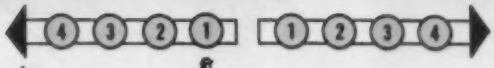

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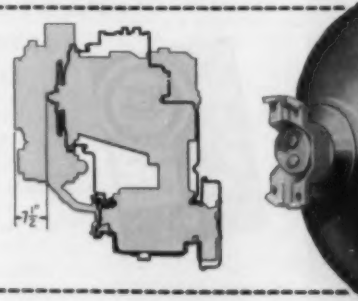

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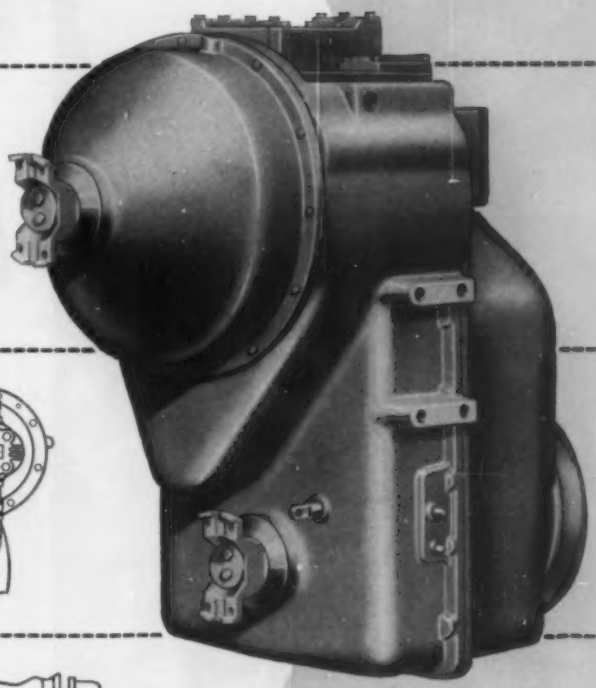

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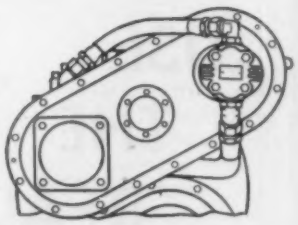
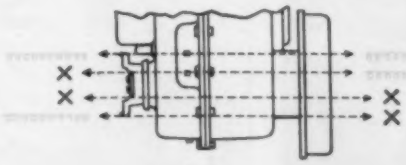


4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



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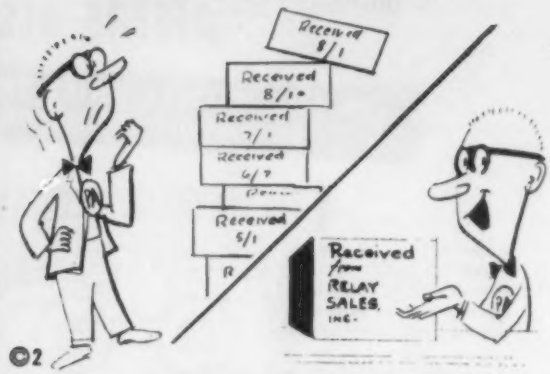

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DESIGN LITERATURE

No-backlash Universal Joint

R E STOKELY, Mechanics Universal Joint Div, Borg Warner Corp, (WADC Technical Report 59-214). PB 161031, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 16 pp. 75¢.

In July '55, Borg Warner Corp began work on the development of a "no-backlash" universal joint in accordance with an Air Force contract. The device differs from a standard universal joint by employing preloaded, tapered roller bearings. This preloading eliminates any play between the bearing and the trunion when a torque load applied on the joint is fully reversed from 8 in.-lb clockwise to 8 in.-lb counterclockwise.

Test specimens were made with extreme care and under laboratory conditions. Hence, it was found that to mass-produce this joint would definitely require special equipment with expert precision work. The preloaded bearings must be absolutely free from foreign matter for maximum operating smoothness. The manufacturing procedures of producing the forgings and the rough machining would be similar to that of a standard universal joint.

Oscillatory Plain Bearings and Lubricants for Airframe Applications

GLAESER, ALLEN, ZIELENBACH, GOLDWAITE, Battelle Memorial Institute, (WADC Technical Report 59-179). AD 216629, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 54 pp. $1.75.

(Full title: The Development of Oscillatory Plain Bearings and Lubricants for Airframe Applications in the Temperature Range — 90 to 1500 F.)

Materials and lubricants for high-temperature airframe journal-type bearings have been developed and evaluated under simulated operating conditions. The temperature range investigated was — 90 to 1500 F. Bearing operation was oscillatory at about 15 cpm. Promising shaft and bushing materials were found for temperatures up to 1500 F.

Graphite and MoS_2 are good plain bearing lubricants for temperatures up to 750 F. Between 750 and 1200 F metal-free phthalocyanine appears to be most effective. For subzero temperatures, graphite or MoS_2 are presumed to be superior to phthalocyanine. For temperatures above 1200 F, bonded lead oxide should be investigated.

Although bearing and shaft materials can be developed for use from — 90 to 1500 F, there is no lubricant which will cover the entire range. This suggests the need for investigating various mixtures of lubricants containing constituents for several temperatures.

Advanced Engineering Mathematics: 2nd Edition

C R WYLIE JR, Professor and Chairman, Dept of Mathematics, Univ of Utah. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 6 x 9½, 696 pp. $9.

This edition presents an introduction to branches of advanced mathematics important to engineers and physicists. Included are determinants and matrices, ordinary and partial differential equations, Fourier series and the Fourier integral, operational calculus developed through the use of the Laplace transform, Bessel functions and Legendre polynominals, vector analysis, the theory of functions of a complex variable, finite differences and difference equations. Also included are such topics from the field of numerical analysis as interpolation, the summation of series, numerical differentiation and integration, the numerical solution of differential equations, harmonics analysis, least squares, and orthogonal polynominals.

Revised edition contains two entirely new chapters on determinants and matrices and on finite differences. The long appendix and glossary devoted to a review of calculus have been omitted, as well as the chapter on fluid mechanics. Also includes answers to all odd-numbered problems.

Heat Capacity of Engine Oils, Lubricants, Fuels, and Hydraulic Fluids

MEDVED, BOLZE, HANSEN, BARGER, Midwest Research Institute, (WADC Technical Report 59-166). PB 161030, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 56 pp. $1.75.

This report (full title: Heat Capacity Determination of Mineral and Synthetic Engine Oils, Lubricants, Fuels, and Hydraulic Fluids, in the Temperature Range 70-500F), in conjunction with WADC Technical Report 58-70, describes a unique, simple, and rapid method for measuring and calculating heat capacities over an extended temperature range.

Adiabatic calorimeters were developed which facilitated the measurement of the heat capacity of liquid materials stable in the 70 to 500 F temperature range. The calorimeters were designed and constructed of glass so that the sample liquid was contained in a Dewar-type flask. Mercury was admitted to the Dewar jacket to rapidly establish temperature equilibrium between the sample and thermostat. Upon reaching equilibrium, the mercury was removed and the Dewar flask evacuated through a trap immersed in liquid nitrogen. This rendered the calorimeter nearly adiabatic.

The method of calculation used the heat-loss rates before and after the heating cycle and the heat-gain rate during the heating cycle. The rate of energy input to the sample and calorimeter was determined by the electrical potential and current.

The heat capacities of 33 lubricants and hydraulic fluids were measured at 80, 185, 290, 395 and 500F, if they were liquid and stable at these temperatures. Duplicate runs were made using two sample sizes, namely, 75 and 150 ml. This enabled calorimeter constants to be obtained without a calibrating standard.

The least-squares method was used to calculate the "best fit" linear relationship between heat capacity and temperature for each of the oils in temperatures of 70 to 500F. The error calculated for these measurements ranged from 3 to 5%.

Other Books of Interest

Method of Charting Paperwork Procedures

X2.3.4-1959. American Standards Assn, 70 E 45th St, New York 17. 8½ x 11, 3 pp. 35¢.

Scientific Information Activities of Federal Agencies

NSF 59-58. Superintendent of Documents, Government Printing Office, Washington 25, DC. 8 x 10, 23 pp. 15¢.

Fixed, Wire-wound Precision Resistors

RS-229. Electronic Industries Assn, 11 W 42nd St, New York 36. 8½ x 11, 17 pp. $1.10.

Powder Metallurgy

Metal Powder Industries Federation, 60 E 42nd St, New York 17. 8 x 9¾, 105 pp. $4.

Proceedings of the Fifteenth Annual Meeting of the Metal Powder Industries Federation.

continued on page 76

1958 References on Fatigue STP 9-J

ASTM, 1916 Race St, Philadelphia 3. 8½ x 11, 76 pp. $3.50.

Minimum-weight Analysis of Symmetrical-multiweb-beam Structures Subjected to Thermal Stress

NASA TN D-104. Robert R McWithey. National Aeronautics and Space Administration, Washington, DC. 7¾ x 10¼, 30 pp. 75¢.

ABSTRACTS FROM THE LITERATURE

Simplified Gear Calculations

Some of the methods useful in calculating dimensional aspects of gear design and production are reviewed. Some of the factors discussed include: the involute function; radians; calculation of distance over "N" teeth; calculation of distance over rollers when number of teeth is known; calculation of dimension over rollers when distance over old rollers is known. Some useful formulas for spur-gear proportioning are included, together with a table of involute function tables.

"Simplified Gear Calculations," Witham and Beveridge. Engineering Materials and Design, April '60, Drury House, Russell St, London WC 2, England.

Design of Heavy-duty Iron Castings

After a brief description of foundry practice, such factors as reduction of stresses in castings, designing for minimum cost, designing for optimum ease of machining are discussed. A page of drawings gives some suggestions for design details.

"Design of High-duty Iron Castings," E. G. Donaldson, International Meehanite Co, Ltd. Engineering Materials and Design, April '60, Drury House, Russell St, London WC 2, England.

Keeping Corrosion Out of Aluminum Structures

Although aimed primarily at designers of transportation equipment, basic considerations should apply to other types of products for use outdoors or with harmful liquids. Included in discussion are some data on choice of materials, joint design, provision for drainage and other factors.

"Tips on Making Aluminum Structures Corrosion-free," Weltman and Bast, Aluminum Co of America. SAE Journal, March '60, 485 Lexington Ave, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 81.

HEAT- AND CORROSION-RESISTANT CASTINGS—Booklet, 64 pp. Information on stainless steel and high-alloy casting selection, design and production. Material is supplemented by 13 tables of technical information. International Nickel Co Inc, 67 Wall St, New York 5.

Circle 350 on Reader Service Card

MOLYBDENUM PRODUCTS—Brochure, 24 pp. Gives sizes, forms, conditions of use, tolerances, weights and methods of identification of products now available for commercial use. Climax Molybdenum Co, Div American Metal Climax Inc, 1270 Ave of the Americas, New York 20.

Circle 351 on Reader Service Card

THERMOCOUPLE ASSEMBLIES—Catalog G100-1, 40 pp. Describes over 100 thermocouple assemblies, including prices, specifications, dimensions and ordering information. Minneapolis-Honeywell Regulator Co, Industrial Div, Wayne and Windrim Aves, Philadelphia 44.

Circle 352 on Reader Service Card

O-RINGS—Handbook 5711, 20 pp. Contains design and test information on high-temperature seals and some 150 fluids and gases to which the O-rings are compatible. Includes recommended O-ring-and-groove design techniques. Parker Seal Co, 10567 Jefferson Blvd, Culver City, Calif.

Circle 353 on Reader Service Card

ENGINEERING'S GREAT CHALLENGE—The 1960's—Three pamphlets, 6 pp each. Three addresses by Hilliard W. Paige, GE executive, covering his views on the country's space effort, the Soviet threat, opportunities and challenges in engineering, and education. General Electric Co, Missile and Space Vehicle Dept, 3198 Chestnut St, Philadelphia 4.

Circle 354 on Reader Service Card

CONVERSION FACTORS—Booklet 1956, 21 pp. Pocket-size compilation of over 800 multiplication factors involved in converting fundamental electrical and magnetic units. Automatic Electric, Northlake, Ill.

Circle 355 on Reader Service Card

PLASTICS PRODUCTS—Catalog 9703, 36 pp. Contains mechanical and electrical properties of the products with graphs of design properties. Illustrates and describes basic shapes available, as well as products made of Teflon, reprocessed tetrafluoroethylene resin and Kel-F. Raybestos-Manhattan Inc, Plastic Products Div, Manheim, Penna.

Circle 356 on Reader Service Card

PILOT LIGHTS—Digest Form L-161B, 24 pp. Describes wide range of pilot-light assemblies and lamps for which they were designed. All units are illustrated life-size. In some groups, charts and circuit diagrams are given. Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.

Circle 357 on Reader Service Card

CAPACITORS, FIXED, PAPER-DIELECTRIC—Bulletin GET-3032, 28 pp. Rating and dimension tables for applications from 100 to 50,000 v dc and from 236 to 660 v ac. Contains graphs, tables, outline drawings, quotation guide forms, description of units and application information. General Electric Co, Schenectady.

Circle 358 on Reader Service Card

NICKEL ALLOY STEELS—Buyers' guide, 28 pp. Covers nickel alloy steel compositions and forms generally available. Part I lists steel service centers, and their nickel steel stocks, alphabetically by states. Part II lists nickel alloy steels (by AISI number when available) and respective steel service centers supplying them. International Nickel Co Inc, 67 Wall St, New York 5.

Circle 359 on Reader Service Card

SENSING DEVICES—Bulletin 1308, 16 pp. Design details and applications of pressure instrumentation, force-balance instruments, unbonded strain-gage and potentiometer pressure transducers, vibration transducers, accelerometers, galvanometers and ceramic and precision optical products are featured. Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.

Circle 360 on Reader Service Card

WELDED DIAPHRAGM BELLOWS—Design guide 77BBP, 16 pp. Presents story of bellows from basic physics through ap-

continued on page 79

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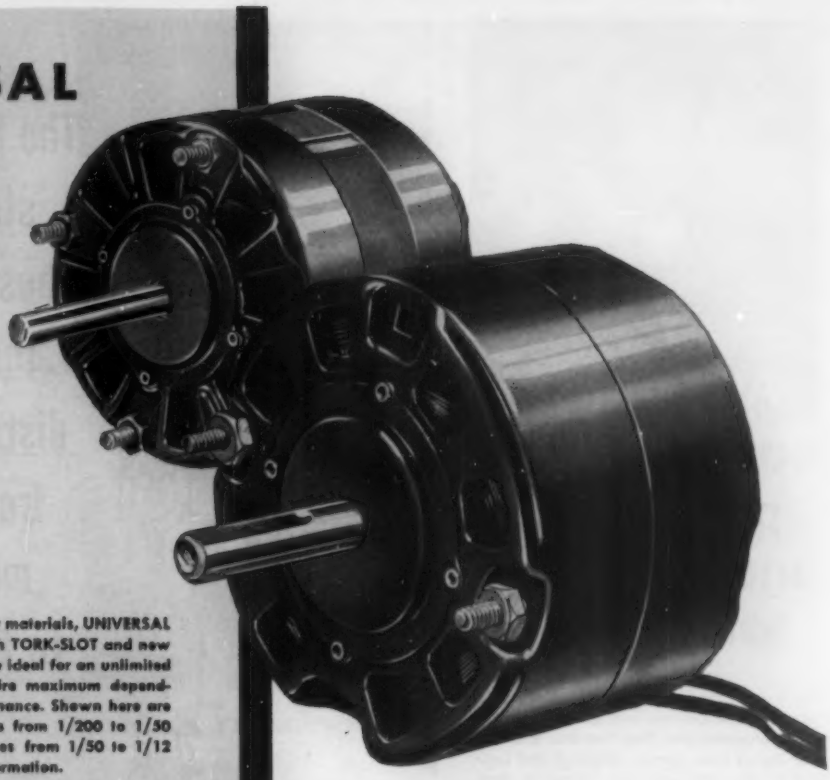

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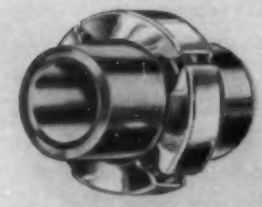

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plications. Includes drawings and specifications of bellows as well as specific illustrations of different types of welded diaphragm bellows. Breeze Corp Inc, 700 Liberty Ave, Union, NJ.

Circle 361 on Reader Service Card

DRAFTING TEMPLET—Pocket-size, semi-opaque templet is for drawing cross-sections of the company's metal-retained seals. Actual size is printed in black above each style. Parker Seal Co, 10567 Jefferson Blvd, Culver City, Calif.

Circle 362 on Reader Service Card

SMALL TUBING—Bulletin 42, 12 pp. Revised edition of tubing guide summarizes significant properties of 84 tubing analyses in seven groups. Presents AISI-type number, available forms, characteristics and applications. Also covers 13 specialty tubing products. Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.

Circle 363 on Reader Service Card

THREE-WAY VALVES—Bulletin 91023, 12 pp. Describes full-capacity valves for air, oil, water, gas, chemical or vacuum service. Supplies specifications, features, dimensions. Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.

Circle 364 on Reader Service Card

MERCURY SWITCHES—Catalog, 12 pp. Specifications on 21 special-purpose mercury switches. Illustrates all 21 units, as well as various terminals and mounting clips for use with the switches. Gordos Corp, 250 Glenwood Ave, Bloomfield, NJ.

Circle 365 on Reader Service Card

HEAVY-DUTY TRANSMISSIONS—Catalog, 8 pp. Standard transmissions custom designed to specific applications is theme of brochure describing units with input-torque capacities of 150 to 2500 ft-lb. Also described and illustrated are transmission arrangements for rotation, location, speed, multiple speeds, shifting, cooling,

continued on page 81

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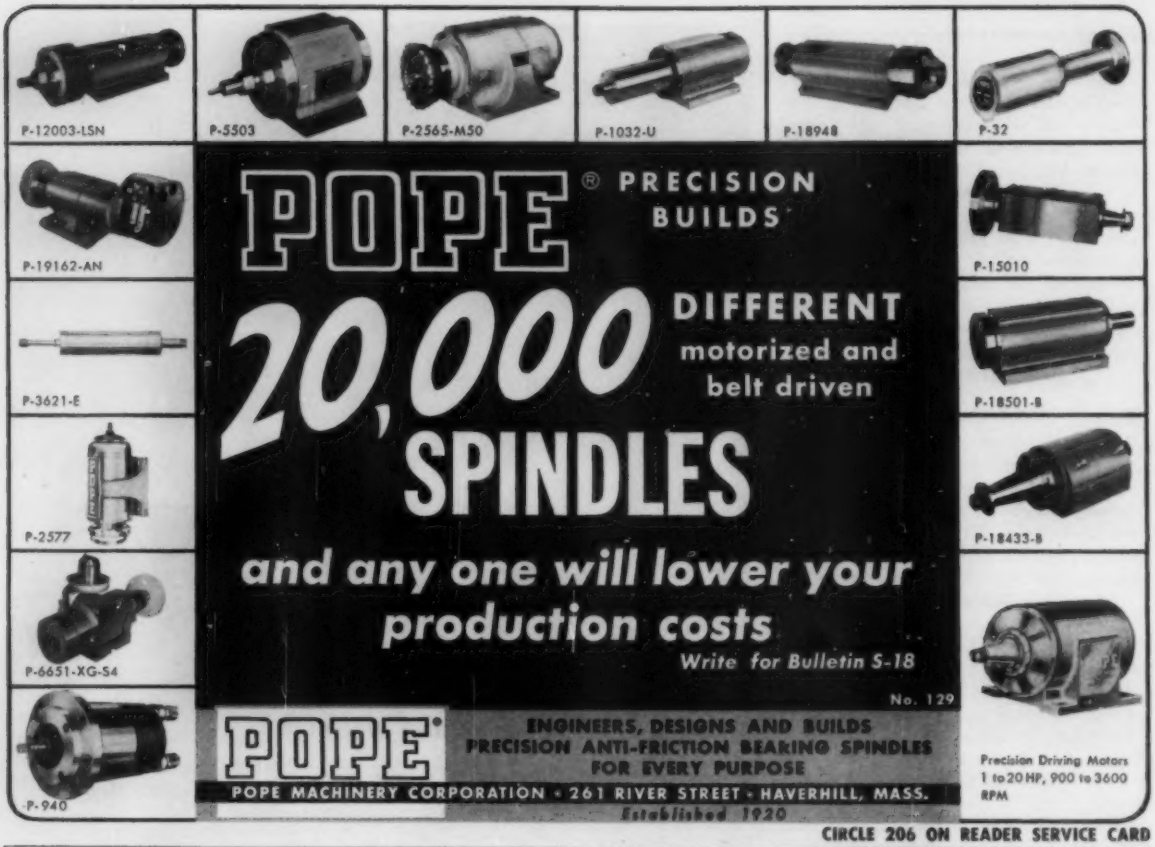

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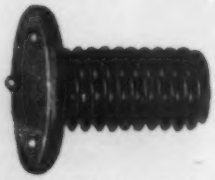

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TEST EQUIPMENT—Short-form catalog, 6 pp. Describes and illustrates, with ratings and prices, line of precision electronic instruments. Boonton Radio Corp, Boonton, NJ.

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DAMPING TECHNIQUES AND METHODS—Bulletin, 4 pp. Describes and discusses techniques and methods of fabrication that incorporate damping in structures. Barry Controls Inc, 700 Pleasant St, Watertown 72, Mass.

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PRECISION THIN-WIDTH INSTRUMENT BEARINGS—Bulletin 6002, 4 pp. Specifications, sizes and ratings of open, single- and double-shielded bearings. Miniature Precision Bearings Inc, Precision Park, Keene, NH.

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Manufacturers who published following literature asked that requests for copies be made on company letterheads.

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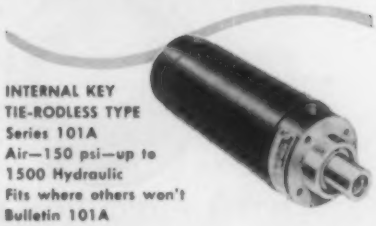

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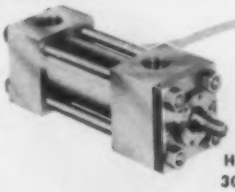

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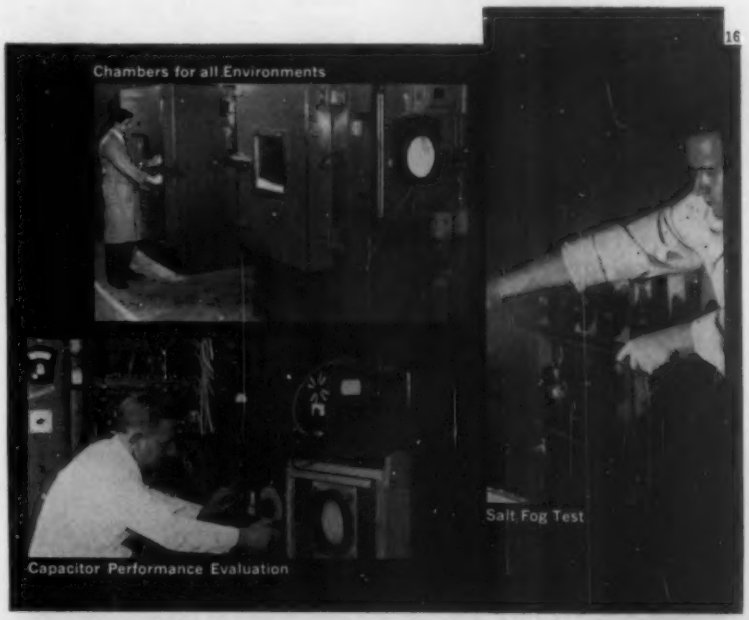

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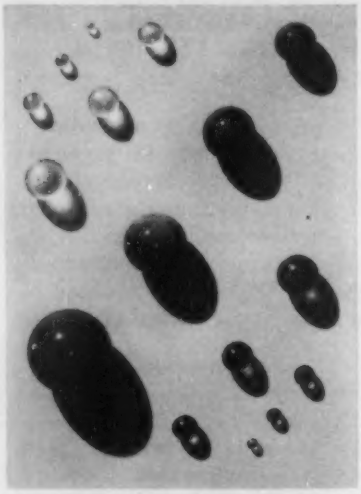

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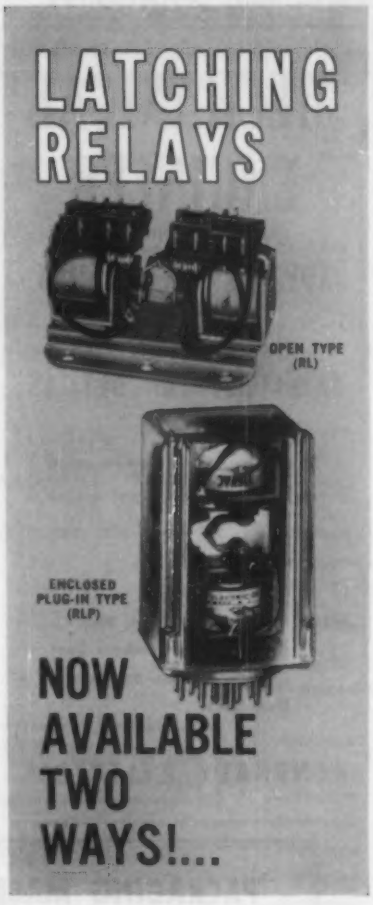

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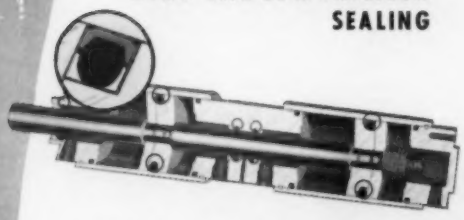

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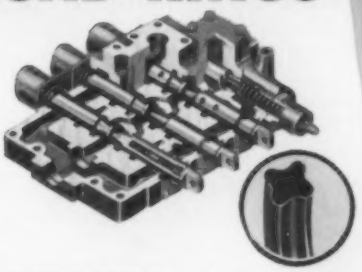

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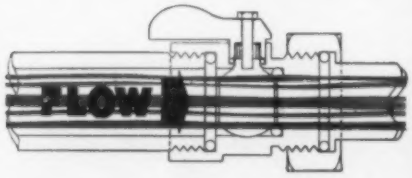

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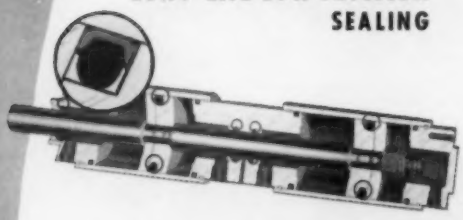

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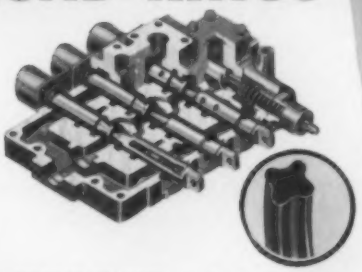

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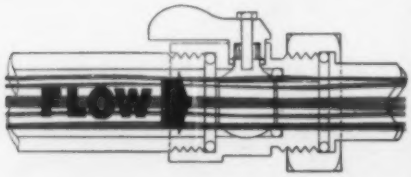

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